CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX L

ENGINEERING

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GENERAL

Calcasieu Lock is located on the Gulf Intracoastal Waterway (GIWW), just east of the Calcasieu River, in Cameron Parish, LA, approximately 10 miles south of Lake Charles, LA. Calcasieu Lock is a critical component of the LA portion of the GIWW, along with its location in the Chenier Plain and being the junction of the Mermentau and Calcasieu River Basins. Therefore the primary Study area is the Lock and immediate vicinity; however a broader approach was taken in assessing environmental, economic and hydraulic conditions and potential impacts. Potential environmental impacts are localized in nature but given the dynamic coastal environment Calcasieu Lock is located in, the Chenier Plain sub region of the coast was evaluated. Hydraulically, potential impacts are local and regional in nature as the operation of the Lock is done in conjunction with other structures in the Mermentau Basin. Therefore, the Mermentau Basin and certain adjacent drainage areas were evaluated.

Drainage alteration measures considered were in three general categories. The categories considered were construction of a new gate structure, pumping stations, and rehabilitation of an existing drainage structure on Black Bayou. Combinations of these categories were configured into the final array of alternatives.

CULVERT STRUCTURE

This measure involves construction of a sluice gate culvert structure south of the existing lock to divert drainage flows away from the existing lock chamber. The gate will only be used during drainage events. The type of gate structure will be determined by the ability to prevent saltwater intrusion in the Mermentau Basin. Typically where passage of vessels is not required, a sluice gate will be used. Machinery is normally hydraulic cylinders, one per gate (max 16 feet wide). Multiple gates can be run from the same hydraulic power unit if openings are staggered.

PUMPING STATION

Reduction of flows through the existing lock chamber could be diminished by the aid of pumping stations. Potential locations for the station and outfall would be either the former GIWW channel at the LA 384 road crossing or the Black Bayou inlet immediately west of LA 384. Hydraulic and Hydrologic (H&H) analysis was done to determine the minimum size necessary to reduce lockage times as well as the maximum pump size necessary to eliminate delays.

REHABILITATE BLACK BAYOU DRAINAGE STRUCTURE

The Black Bayou Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) project was completed in 2006 by the Natural Resources Conservation Service (NRCS). During the intervening period a prolonged drought has limited the structures effectiveness. In 2011 the forebays of the structures were filled in the prevent undermining of the structure due to seepage underneath it. This measure would involve complete replacement of the structure with adequate foundations and scour protection. The ten culvert design, with 10-foot x 10-foot openings, will be re-evaluated and adjusted as necessary to maximize reduction in navigation delays.

FINAL ARRAY OF ALTERNATIVES

Alternative 1: An 82-foot-wide and 100-foot-long culvert that consists of five 9-foot x 14-foot openings that will allow for the passage of the additional flow. The structure will be generally within the alignment of the previously proposed south lock. The outfall and intakes will need to be excavated with material being beneficially used for marsh creation.

Alternative 2: A 3,700 cubic feet per second (cfs) pumping station would be constructed generally within the alignment of the previously proposed south lock. The outfall will need to be excavated with material being beneficially used for marsh creation.

Alternative 3: Supplemental Culverts would be added to the Black Bayou NRCS structure to increase its capacity and operate in conjunctions with it. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 3.0 North American Vertical Datum of 1988 (NAVD88). Black Bayou Dredging to the east and west of the NRCS structure will also occur.

Alternative 4: A 2,000 CFS Pumping Station would be constructed adjacent and north of the existing Black Bayou NRCS structure and operate in conjunction with it. The pump would likely be west of the road with pipes running under the roadway. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 NAVD88. Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative operates in conjunction with the Black Bayou structure. This will require the Corps to take over Operation and Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) of the structure once its 20-year project life under CWPRA ends.

NOTE: Following IPR#1 in February 2013, it was determined that a 1,000 cfs pump would be insufficient to overcome the natural tendency to drain through the lock when the sector gates were open. Additional HH analysis indicated that a 2,000 cfs pump operating in conjunction with the Black Bayou structure would be sufficient to provide the drainage capacity the lock currently provides.

Alternative 5: A 3,700 CFS Pumping Station would be constructed adjacent and north of the existing Black Bayou NRCS structure. The pump would likely be west of the road with pipes running under the roadway. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 NAVD88. Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative operates independent of the Black Bayou Structure.

HYDROLOGY AND HYDRAULICS

I. INTRODUCTION

In 2009, an in-house feasibility study was authorized for approximately 4,000 square miles in the southwestern Louisiana. The entire area is bounded on the north by US 190, on the west by the Calcasieu River, in the south by the Gulf of Mexico, and on the east by the Vermillion River and I-49. Inefficient drainage through the existing Calcasieu Lock is causing navigational traffic to be delayed, and this study is needed to find ways of improving this problem. Although drainage is not part of the study, it was found that reduced locking times cannot be achieved without improving drainage.

II. CLIMATOLOGY

A. Climate. The study area has a subtropical marine climate. Located in a subtropical latitude, its climate is influenced by the many water surfaces of the lakes, streams, and Gulf of Mexico. Throughout the year, these water bodies modify the relative humidity and temperature conditions, decreasing the range between the extremes. When southern winds prevail, these effects are increased, imparting the characteristics of a marine climate.

The area has mild winters and hot, humid summers. During the summer, prevailing southerly winds produce conditions favorable for afternoon thundershowers. In the colder seasons, the area is subjected to frontal movements that produce squalls and sudden temperature drops. River fogs are prevalent in the winter and spring when the temperature of the Calcasieu River and the GIWW are somewhat colder than the air temperature.

B. Temperature. Records of temperature are available from “Climatological Data” for Louisiana, published by the National Climatic Center. The study area can be described by using the normal temperature data observed at Hackberry 8 SSW, Lake Charles Airport, and Jennings stations. These stations are shown in table L-1 with the monthly and annual mean normals which are based on the period 1971 to 2010.The average annual mean normal temperature is 68.6^{o}F, with monthly mean temperature normal varying from 82.9^{o}F in July to 49.8^{o}F in January. Extreme temperatures since 1971 were 10^{o}F on Dec 24, 1989 and 107^{o}F on Aug 31, 2000 at the Jennings and Lake Charles Airport stations.

C. Precipitation. Records of precipitation are also available in publications by the National Climatic Center. Four stations in the study area have been used to show the rainfall data for the study area. All stations have normal precipitation records which are based on the period 1971-2010. These gages include Hackberry 8 SSW, Bell City 13 SW, Jennings, and Lake Charles Airport. Table L-2 lists the monthly and annual normals of the four stations. The average annual normal rainfall of the four stations is 54.06 inches. The wettest normal month is July with a monthly average of 6.18 inches. April is the driest normal month averaging 2.99 inches. Of the three stations, Bell City 13 SW has the maximum normal month with 7.32 inches occurring in July, and Lake Charles AP had the greatest day with 15.67 inches of rain falling on May16, 1980.

D. Wind. Onshore wind velocities based on records at the Lake Charles Municipal Airport average 8.7 mph and blow from the south during most of the year. Based on the Summary of Synoptic Meteorological Observations taken by the U.S. Naval Weather Service Command over the period 1953-1971, offshore winds average 13.6 mph, with the predominately wind directions being southeast and east over the year.

E. Stream Gaging Data. Stream gaging data are available from five stations in the study area. The stations with their maximum and minimum extreme stages are shown in table L-3. Discharge records are not taken in the study area.

F. Floods and Storms of Record. There have been several floods in the study area caused by runoff from heavy rainfall. Following is a brief discussion of some of the major events that occurred over the last 30 years, including Hurricanes Juan, Lili, and Katrina and Tropical Storms Frances, Allison, and Isidore.

May 1978. Extremely heavy rain that began early on 3 May and continued throughout the day caused widespread flooding over the New Orleans metropolitan area. Storm totals for Audubon Park and Moisant Airport during 2-3 May were 10.6 and 6.8 inches, respectively. The Algiers station received a total of 11.72 inches during 3-4 May.

April 1980. There were two separate storms during April 1980.The first event occurred 2-3 April and averaged over 5 inches of rain throughout the New Orleans metropolitan area. The Audubon Park station measured nearly 7 inches on 2 April. This storm set the stage for the intense 12-13 April event, which averaged 9.5 inches over the same area. Most of the rain fell during the morning of the 13^{th}. The Algiers gage had a 2-day storm total of 11.86 inches with 9.71 inches falling on the 13 April. Moisant Airport had a maximum 24-hour rainfall of 7.95 inches on the 13^{th}. Flash flooding occurred rapidly, since the ground was already heavily saturated from the first April storm. Orleans and Jefferson Parishes experienced the greatest flooding.

October 1985. Hurricane Juan (25-31 October) was responsible for this flood. Juan was in the vicinity of Louisiana for 6 days. Most flooding was associated with the storm surge and backwater flooding produced by prolonged, strong easterly to southerly winds. Backwater flooding was aggravated by excessive rainfall that fell mostly during the first days of the storm. In the New Orleans metropolitan area, 3-day storm totals (27-29 October) ranged from 5 to 10 inches, with 10.33 inches at Gretna, 7.59 inches at Algiers, and 7.55 inches at Moisant Airport. This storm also caused the peak stages of 4.74 feet NGVD at IWW at Harvey Lock and 4.25 feet NGVD on Bayou Barataria at Barataria.

April 1988. This flood was associated with squall lines ahead of a slow-moving cold front during 1-3 April over the New Orleans area. Storm totals were over 10 inches at several stations. Most of the rain fell in a 12-hour period on 2 April, with nearly 9 inches recorded throughout the area. Some 3-day storm totals reported were 11.08 inches at Gretna, 10.72 inches at Algiers, and 10.63 inches at Audubon Park.

Table L-1. Mean Monthly and Annual Temperature (^{o}F)
30-year Normals (1971-2010)

Station	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Hackberry 8 SSW	51.1	54.7	61.6	68.1	75.5	81.2	82.9	M	79.3	70.8	61.5	53.9	M
Lake Charles AP	50.9	54.4	61.0	67.3	74.9	80.5	8206	82.4	78.4	69.5	60.1	53.3	69.9
Jennings	49.8	53.4	60.4	66.8	74.7	80.0	81.8	81.6	77.9	68.8	59.5	52.3	67.3
Average	50.7	54.2	61.0	67.4	75.0	80.6	82.4	82.0	78.5	69.7	60.4	53.2	68.6

Source: National Climatic Center

Table L-2. Monthly and Annual Normal Precipitation (Inches)
(1971-2010)

Station	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Hackberry 8 SSW	5.70	3.46	3.78	4.01	4.92	6.63	6.62	5.47	5.53	4.37	4.72	4.37	59.58
Bell City 13 SW	3.02	5.26	1.63	0.33	2.53	3.47	7.32	4.43	2.55	2.24	3.87	2.19	38.84
Jennings	6.15	3.80	4.48	3.97	5.51	5.63	5.66	4.74	5.83	4.29	5.26	5.22	60.64
Lake Charles AP	5.52	3.28	3.54	3.64	6.06	6.07	5.13	4.85	5.95	3.94	4.03	1.96	57.19
Average	5.10	3.95	3.36	2.99	4.76	5.45	6.18	4.87	4.97	3.71	4.47	3.44	54.06

Source: National Climatic Center

Table L-3. Stream Gaging Data

			Record Stages (ft NGVD)			
Station	**Latitude/Longitude**	**Period of Record**	**Max[1]**	**Date**	**Min**	**Date**
Calcasieu Lock East	30-05-14 / 93-17-2	1951-2011	5.79a	28Jun1957	-1.21	08Jul1951
Calcasieu Lock West	30-05-14 / 93-17-28	1951-2011	7.99a	27Jun1957	-2.13	28Feb1984
Catfish Point CS North	29-51-48 / 92-51-00	1951-2011	8.30a	27Jun1957	-0.80	26Dec1975
Lacassine Wildlife Refuge	30-00-09 / 92-46-52	1947-2011	6.50	04Nov1985	-0.47	10Jun1951
Cameron	29-46-30 / 93-20-46	1939-2011	12.90a	27Jun1957	-3.12	25Feb1965

Source: U.S. Army Corps of Engineers, New Orleans District
[1] a=caused by hurricane

November 1989. A narrow, almost stationary east-west band of strong thunderstorms developed across the New Orleans metropolitan area on the morning of 7 November. As a result, heavy rains persisted over the study area before decreasing in the afternoon. The prolonged storm triggered flash floods throughout the area. Rainfall amounts of 8-12 inches were common from 9:00 AM to 6:00 PM during this day. In Jefferson Parish, rainfall reports from several of the parish's pumping stations indicated 10-12 inches of rain occurred between 8:00 AM and 2:00 PM. The Gretna gage totaled 17.13 inches over 7-9 November, with 13.70 inches recorded on the 8th. The Algiers station recorded 10.85 inches for the same period. Many homes throughout the metropolitan area received some type of water damage.

May 1995. This flood resulted from torrential rain that accompanied 50 miles per hour winds and tornadoes. Intense rainfall began around 6:00 PM on 8 May and continued until midnight. Two to three inches of rain per hour fell for several hours during the peak storm period. At Moisant Airport 9.69 inches of rain fell in three hours, and 12.24 inches fell in less than 5 hours. The highest 1-hour rainfall total of 6.5 inches was reported at a National Weather Service (NWS) hourly recording station at Audubon Park. Three- and six-hour totals from this storm exceeded the same hourly totals for the 1978 and 1989 rainfall events and when compared to rainfall totals in NWS Technical Paper (TP) No. 40, 3 and 6 hour rainfall totals reported for this storm exceeded amounts projected for 500-year frequency events. Jefferson Parish experienced extensive flooding from this storm and recorded a maximum 19.53 inches of rainfall at a local gage. Other measurements include 13.70 inches at Gretna and 10.92 inches at Algiers, both occurring on 9 May.

September 1998. Tropical Storm Frances (8-13 September) brought torrential rains and strong winds to southeastern Louisiana. Storm totals topped 15 to 20 inches over much of the greater New Orleans area. Algiers and Gretna received 19.91 and 17.37 inches, respectively, over a 4 day period (10-13 September), while Audubon totaled 16.9 inches over 8-13 September. Frances set a new peak stage at the Intracoastal Waterway at Algiers Lock with a 4.63 feet NGVD reading.

June 2001. Tropical Storm Allison (6-11 June) brought extensive urban flooding in metropolitan areas around New Orleans. Rainfall totals over this period were 21.3 inches at Gretna and 14.28 inches at Audubon.

September 2002. Tropical Storm Isidore (18-26 September) first made landfall at Grand Isle, before moving across Lake Pontchartrain to the north. Tide levels were 4 to 6 feet above normal, but many areas flooded due to heavy rainfall. The rainfall totals near the study area ranged from 18.50 inches at the New Orleans Algiers station to 12.78 inches at Terrytown. Algiers recorded 15.34 inches on the 26th.

October 2002. Hurricane Lili (23 September - 3 October) was originally a Category 4 hurricane and first made landfall as a downgraded Category 2 hurricane near Intracoastal City, LA to the west. Wind gusts up to 61 mph were reported near the study area. Rainfall estimates were rather low at 5 inches, due to the rapid forward movement of the storm. Tide levels were 4 to 7 feet above normal, with many areas outside of the study area being flooded. The stage at Harvey Canal at Lapalco reached 9.84 feet NGVD on the 5th.

August 2005. Hurricane Katrina (29 August) first made landfall near Empire, LA as a slow moving Category 4 hurricane, and continued on a northerly track. The Slidell rain gage recorded at least

7 inches of rainfall, whereas rainfall totals from other gages are not available. Storm surge ranged from 14 feet near the eye wall to 32 feet at the center. Many of the hurricane protection structures in the New Orleans and Chalmette areas were overtopped, and many failed as a consequence, causing catastrophic loss of property and life. However, the west bank area of New Orleans is completely surrounded by levees which were not overtopped, mainly due to its distance from Lake Pontchartrain and being bordered by the Mississippi River and its two levees. Gage data from all nearby gages was insufficient.

September 2005. Hurricane Rita (September 24-26) Hurricane Rita first made landfall just west of Johnson's Bayou, LA as a Category 3 hurricane after downgrading from a 180 mph Category 5 hurricane. The coastal communities of southwest Louisiana were all heavily damaged or totally destroyed by the 20-foot surge. The storm surge also completely overtopped the Calcasieu Lock structure. Many low lying areas in Lake Charles also flooded.

September 2008. Hurricane Gustav (August 25-September 2) first made landfall on the morning of September 1, 2008 near Cocodrie, LA as a Category 2 hurricane with 105 mph winds. Twelve hours later, Gustav was downgraded to a Tropical Storm with 60 mph winds near Alexandria, LA. Due to improved hurricane protection measures made in the metropolitan New Orleans area since 2005, the entire city was spared from damages due to storm surge. Rainfall amounts were:

September 2008. Hurricane Ike (September 1-14) first made landfall near Galveston, Texas as a Category 2 hurricane with 110 mph winds on September 13, 2008. Although landfall was to the west in Texas, this storm caused extensive flooding due to storm surge created by the large wind field along the south central and southwest coastal parishes of Louisiana. The storm surge also completely overtopped the Calcasieu Lock structure.

G. Tides. Tides in the vicinity of Calcasieu Lock are predominantly semi-diurnal. The tidal range is about 0.8 foot NGVD with a mean high tide of 2.1 feet NGVD and a mean low tide of 1.3 feet NGVD.

III. HYDROLOGY

A. General. Rainfall runoff from the higher elevated farm lands north of I-10 drains into the flat wetlands that are trapped by the shell ridge at the Gulf of Mexico. The normal drainage path would have been for this runoff to drain into the Mermentau River, which would have enlarged itself on its way to the gulf during high rainfall events, but this is now routed into an easterly or westerly flow into the GIWW. The area is generally flat in topography, especially south of the GIWW where water surface elevations can lie between -3.0 feet and +4.0 feet North American Vertical Datum of 1988 (NAVD88), with an average overall elevation for the entire project area of +27.0 feet NAVD88. The minimum elevation is -22.0 feet NAVD88 and the maximum elevation is 122.0 feet NAVD88, but the maximum water surface elevation is only +44.0 feet NAVD88, which is located at the far northeastern edge of the project.

B. Study Area Description. The area gradually drains through numerous bayous that flow in a south or south westerly direction, converging into Lake Arthur. From this point, the Mermentau River retains its original name, even though Lake Arthur and Grand Lake are large fresh water lakes that connect the two main segments of the Mermentau River. At the approximate junction of Bayou Lacassine and the Mermentau River, the GIWW diverts flow into a westerly direction towards the

Calcasieu Lock, or in an easterly direction towards the Leeland Bowman Lock. The remainder of the flow that cannot be handled by the GIWW drains through the southern part of the Mermentau River and the Catfish Point Control Structure just north of the town of Grand Chenier. The lock structures of Leeland Bowman and Schooner Bayou are included in this model, but were shown to have no effect from the 33-mile backwater profile created by the Calcasieu Lock. Since there are no protective dikes on the north side of this backwater profile, a certain amount of the flow has been known to flood these agricultural lands, especially if the east gage at the Calcasieu Lock rises above three feet. Only in the extreme rainfall events is this flow diverted towards the Catfish Point Control Structure to the south. The only way to find this out was to include the excessively large area that is now in the model.

C. Methodology. In flat terrain such as this area, the use of hydrologic and hydraulic storage areas is the best course of action. In this case, 81 storage areas wound up being the final choice, which includes 5 inland lakes. The size and location of each storage area is critical to the success of the project, so this must be taken as the first step and finalized as soon as possible. New technology using LIDAR and GIS software allows one to view the topography of an area in much greater detail and contrast, as shown in the color-shaded relief map below. Since the area is so large, more detail was needed on a series of enlarged areas showing topography, especially where the higher lands in the north meet the flat lands in the south. The project area and storage areas are outlined in black. The “hotter” colors of orange and red depict the higher elevations and the “colder” colors of dark blue depict the lower elevations. For this purpose, a legend with the elevations is not needed, because the choice of storage area boundaries is usually based upon sudden change in colors, caused by canals, main roads, and ridges.

It was originally assumed that the area just to the south of Alexandria would also be needed for the study, but this northern boundary was later lowered to US 190 between Kinder and Opelousas, Louisiana due to the large amounts of sandy soil that absorb the runoff. The lower Mermentau River was represented by five additional storage areas.

Once the storage areas were determined, hydrologic parameters and hydraulic storage curves were derived with software. One runoff hydrograph will be produced for each storage area and for each event. This will then be used as input for the hydraulic software, and allowed to enter the system of storage area connections and any available waterway through one artificial lateral weir located at the lowest point on the boundary of each storage area. The size of this lateral weir is adjusted in the calibration phase until the desired gage readings have been achieved. Lag times should fall between 30 minutes and 3 hours, so the choice of storage area size could affect this to the point that the boundaries may need to be redrawn for some. The advantage of this method is that both hydrologic and hydraulic parameters are adjusted during calibration such that the target elevations of the gages are reached to within 0.20 foot. Target elevations were derived from adjusted gage data available for all four locks or control structures.

Samples of detailed topography are shown in figures L-1 through L-3.

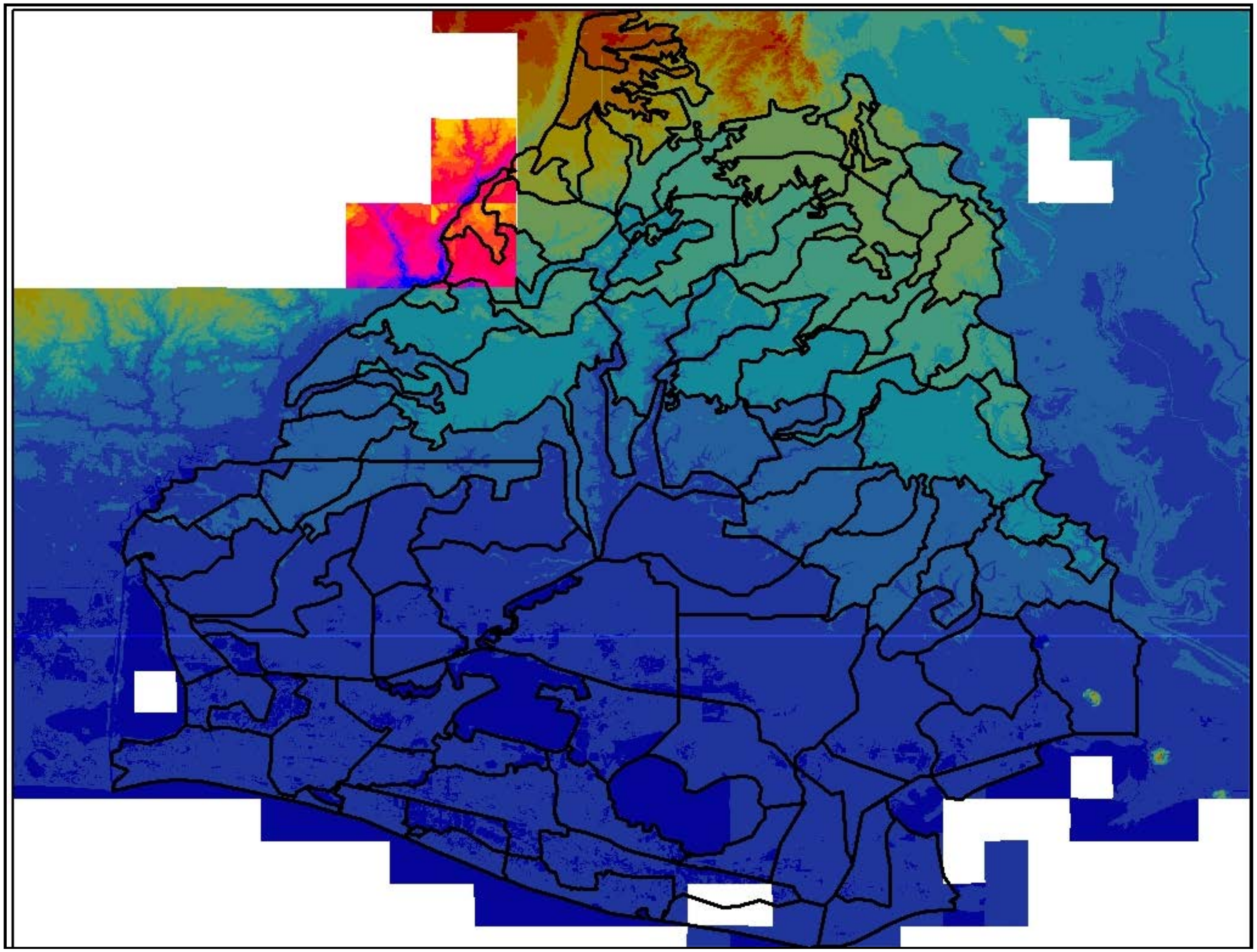

Figure L-1. Color-Shaded Relief Map From LIDAR as an Overview of Area Initially Considered To Cover the Entire Project

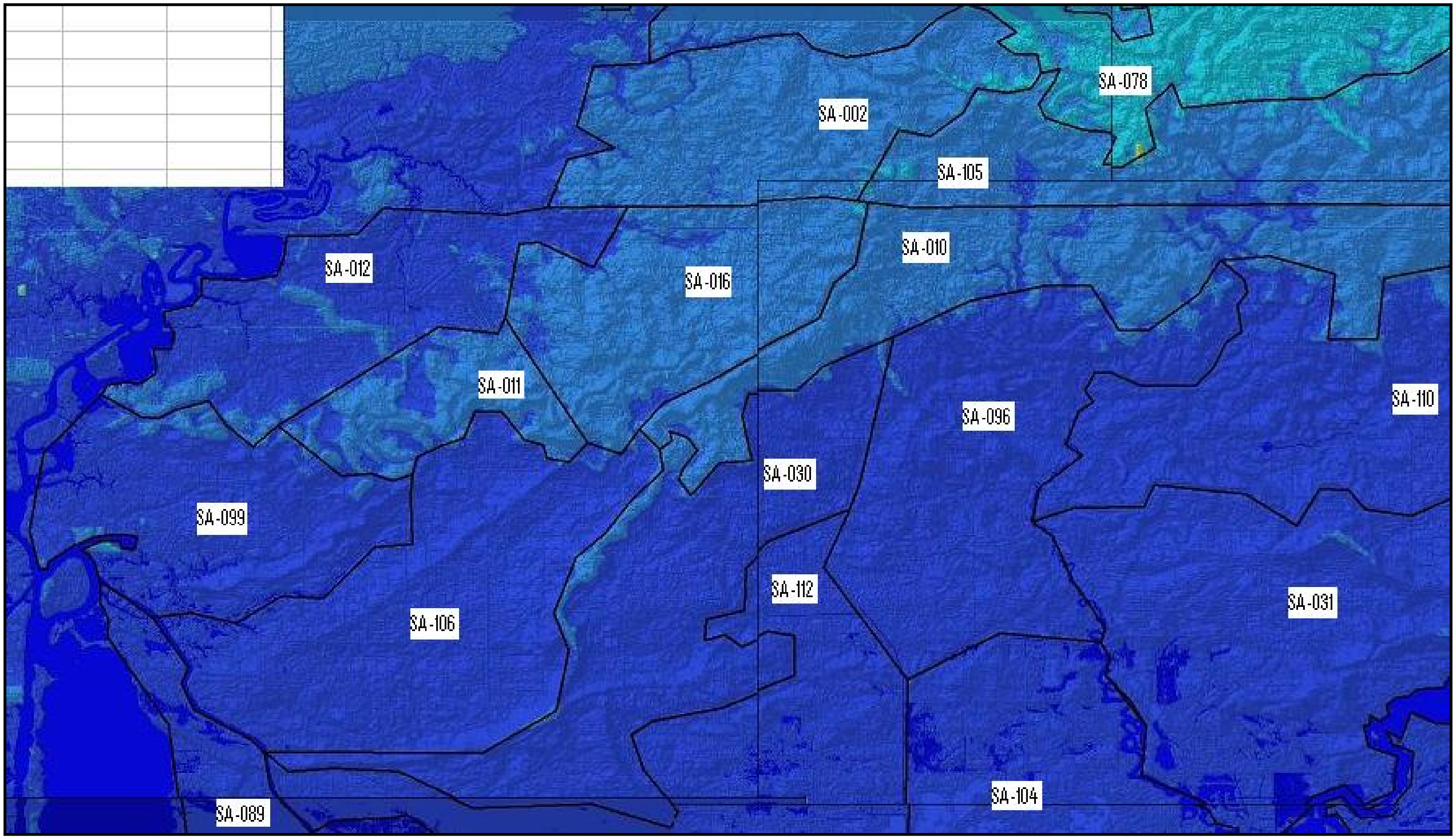

Figure L-2. Sample Color Shaded Relief Map From LIDAR Near Lake Charles, LA

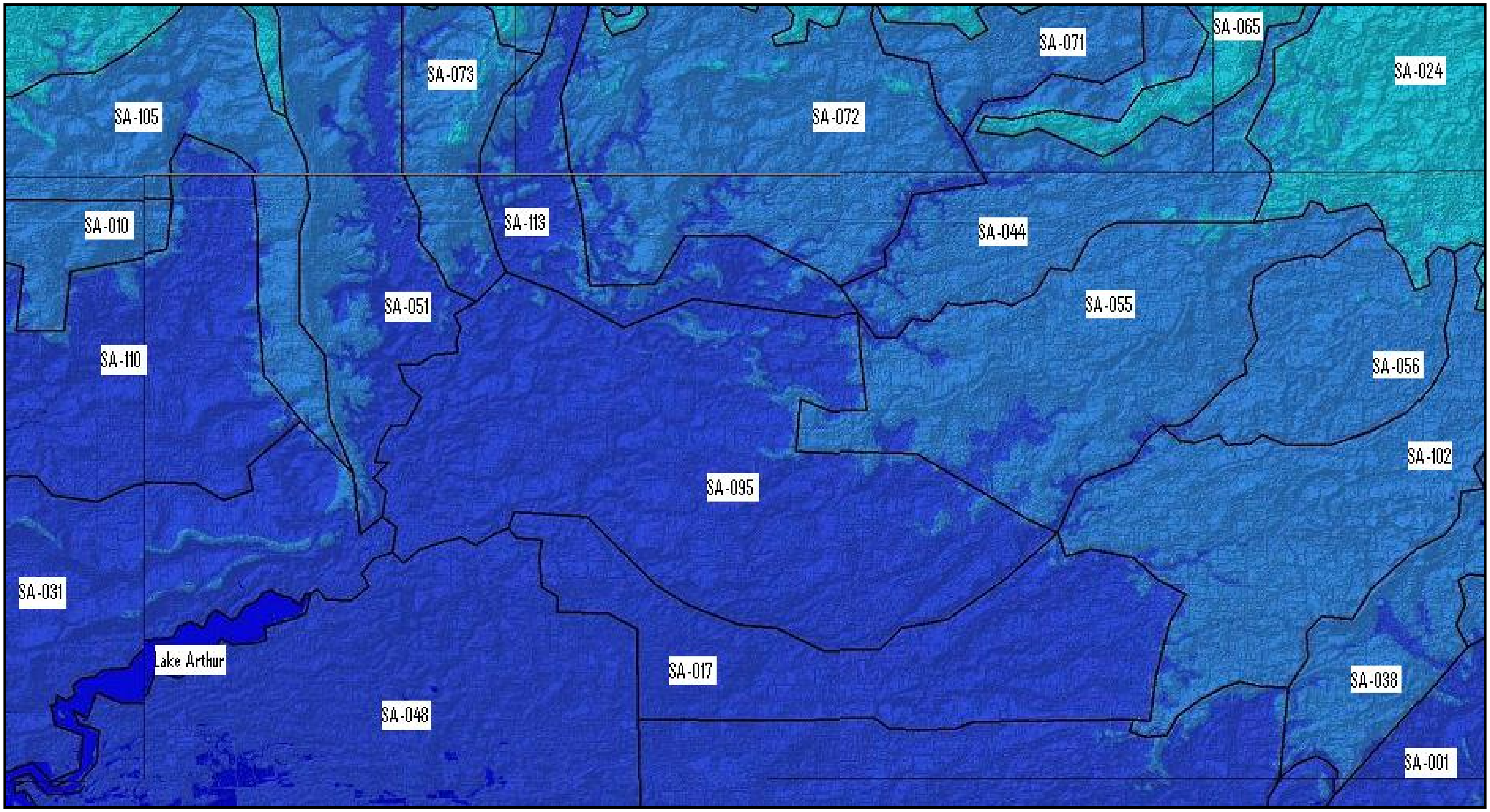

Figure L-3. Sample Color Shaded Relief Map From LIDAR Near Jennings, LA

D. Land Use. The Soil Conservation Service (SCS) Curve Number (CN) Method was used for mostly Class D soils to depict current land usage. The numbers range from a low value of 77 for forested areas to a high value of 98 for open water or concrete areas. GIS was used to generate a CN per storage area. There are nine parishes in this basin. Land type and the Hydrologic Soil Type were used in GIS to generate one CN per storage area. The CNs are based upon Table 2-2a, *Runoff curve number for urban areas,* from TR55 "Urban Hydrology for Small Watersheds". This table was used to translate the land type Class Id required by GIS. When a sub-storage area fell between parishes a weighted curve number was recalculated as shown in "Weighted CN From GIS" worksheet.

The soil cover complex and associated runoff curve number procedure outlined in the SCS National Engineering Handbook (SCS, 1972) were used to represent runoff potential from the watershed. Existing land uses were determined by using Class D soils for most of the entire basin, recent aerial photos, and GIS software. The results are tabulated in table L-4 as percentages for each runoff curve number for the entire project watershed.

Table L-4. Percentages for Runoff Curve Numbers

Land Use	Percent	CN
Forested	2.02%	77
Open land with Trees	4.83%	79
Open land	36.88%	80
Wetlands	13.80%	82
New Development	0.00%	84
Open Residential	4.28%	86
Open-dense Residential	3.41%	88
Dense-open Residential	27.42%	90
Dense Residential	0.97%	92
Schools and Research	0.67%	94
Industrial Areas	1.01%	96
Open Water or Concrete	4.72%	98

Once the weighted SCS Curve Number was calculated for each of the storage areas, all other parameters were able to be derived. Table L-5 shows all input parameters to HEC-HMS Hydrologic Modeling System software. The distance used to compute lag time and Time of Concentration was also found by using GIS software and the longest distance to each connection for each storage area. The rainfall event of November 5, 2002 showed a maximum of 4.84 inches in 6 hours. The isohyetal method was used to compute actual rainfall for each basin, and is also shown below. This method will be explained in greater detail in the next section. No further adjustment of these input parameters is necessary once calibration is achieved.

Drainage Paths were first drawn in red upon color shaded relief maps created from LIDAR. Once the lowest perimeter elevation and location were found, storage area connections were created in HEC-RAS to represent the end of each drainage path. This was then updated to the images shown as modified pink lines. Since most of the modified drainage paths were shorter than the original assumed drainage paths, this would only reduce most of the lag times and then create steeper runoff hydrographs of less duration. As for the very few storage areas that experienced longer drainage paths as a result, these were all found to be in locations such as to have almost no effect upon the Calcasieu Lock in question. Therefore, the modified drainage paths were not recalculated and updated to HEC-HMS. A few sample images are shown in figures L-4 and L-5.

Table L-5. Entire Hydrology Input to HEC-HMS

Storage	Area (sq. mi.)	Lag Time (min)	Time of Concentration (min)	SCS CN	Initial Abstraction (in.)	Impervious %
SA-001	25.960	382	229	87.34	0.29	87
SA-002	42.246	430	258	87.75	0.28	87
SA-006	31.210	202	121	98.78	0.02	98
SA-007	51.076	422	253	89.46	0.24	89
SA-008	29.057	455	273	88.60	0.26	88
SA-009	10.210	303	182	98.41	0.03	98
SA-010	50.990	553	332	89.66	0.23	89
SA-011	18.480	255	153	87.78	0.28	87
SA-012	39.070	465	279	85.70	0.33	85
SA-013	32.180	418	251	94.42	0.12	94
SA-014	72.690	392	235	97.55	0.05	97
SA-015	65.830	362	217	98.86	0.02	98
SA-016	39.460	417	250	88.35	0.26	88
SA-017	55.340	337	202	91.37	0.19	91
SA-019	51.270	400	240	98.83	0.02	98
SA-021	72.810	192	115	98.61	0.03	98
SA-023	81.790	383	230	96.99	0.06	96
SA-024	118.419	540	324	84.60	0.36	84
SA-029	27.445	217	130	80.87	0.47	80
SA-030	58.040	682	409	88.83	0.25	88
SA-031	98.470	638	383	91.57	0.18	91
SA-032	27.276	305	183	76.54	0.61	76
SA-033	164.210	647	388	91.26	0.19	91
SA-034	71.050	462	277	97.75	0.05	97
SA-036	21.600	195	117	98.79	0.02	98
SA-038	53.031	760	456	87.09	0.30	87
SA-039	53.761	652	391	86.85	0.30	86
SA-040	70.310	382	229	98.63	0.03	98
SA-041	42.029	385	231	83.95	0.38	83
SA-042	59.967	695	417	86.48	0.31	86
SA-044	48.059	728	437	85.07	0.35	85
SA-046	58.730	475	285	98.89	0.02	98
SA-048	142.570	602	361	92.30	0.17	92
SA-049	80.210	445	267	98.87	0.02	98
SA-051	54.210	978	587	86.66	0.31	86
SA-054	8.410	117	70	98.40	0.03	98
SA-055	63.390	602	361	90.63	0.21	90
SA-056	28.530	393	236	90.06	0.22	90
SA-065	33.458	398	239	87.37	0.29	87
SA-066	88.150	492	295	98.99	0.02	98
SA-067	53.080	420	252	97.54	0.05	97
SA-069	53.493	468	281	88.94	0.25	88
SA-070	98.130	610	366	90.27	0.22	90

Table L-5. Entire Hydrology Input to HEC-HMS

Storage	Area (sq. mi.)	Lag Time (min)	Time of Concentration (min)	SCS CN	Initial Abstraction (in.)	Impervious %
SA-071	15.872	285	171	86.29	0.32	86
SA-072	76.810	578	347	81.14	0.46	81
SA-073	21.590	392	235	86.01	0.33	86
SA-074	34.090	240	144	95.75	0.09	95
SA-075	9.130	183	110	83.01	0.41	83
SA-076	21.217	337	202	87.15	0.29	87
SA-077	42.668	570	342	81.07	0.47	81
SA-078	133.646	443	266	89.79	0.23	89
SA-079	24.720	135	81	98.71	0.03	98
SA-080	8.873	162	97	90.74	0.20	90
SA-083	30.670	187	112	87.66	0.28	87
SA-086	12.610	182	109	98.86	0.02	98
SA-087	31.860	390	234	98.99	0.02	98
SA-089	28.050	330	198	96.27	0.08	96
SA-090	30.310	195	117	99.00	0.02	99
SA-091	76.230	288	173	95.67	0.09	95
SA-092	26.110	270	162	98.89	0.02	98
SA-093	2.000	142	85	98.88	0.02	98
SA-094	61.160	463	278	86.45	0.31	86
SA-095	110.930	430	258	90.31	0.21	90
SA-096	60.290	610	366	88.80	0.25	88
SA-097	19.670	90	54	98.97	0.02	98
SA-098	5.440	188	113	98.99	0.02	98
SA-099	40.900	350	210	88.10	0.27	88
SA-100	28.170	333	200	87.56	0.28	87
SA-101	23.190	140	84	98.42	0.03	98
SA-102	61.860	757	454	90.20	0.22	90
SA-103	63.637	305	183	89.18	0.24	89
SA-104	54.800	373	224	95.71	0.09	95
SA-105	70.330	687	412	90.03	0.22	90
SA-106	63.830	585	351	89.72	0.23	89
SA-107	44.890	152	91	98.97	0.02	98
SA-110	81.310	863	518	90.94	0.20	90
SA-111	46.040	198	119	98.96	0.02	98
SA-112	85.010	573	344	94.71	0.11	94
SA-113	27.590	475	285	83.10	0.41	83
SA-114	9.040	235	141	98.98	0.02	98
SA-115	11.860	265	159	90.03	0.22	90
Lower	1.000	273	164	98.00	0.04	98
Lower	1.000	170	102	98.00	0.04	98
Lower	1.000	272	163	98.00	0.04	98
Lower	1.000	155	93	98.00	0.04	98
Old Lower	1.000	158	95	98.00	0.04	98

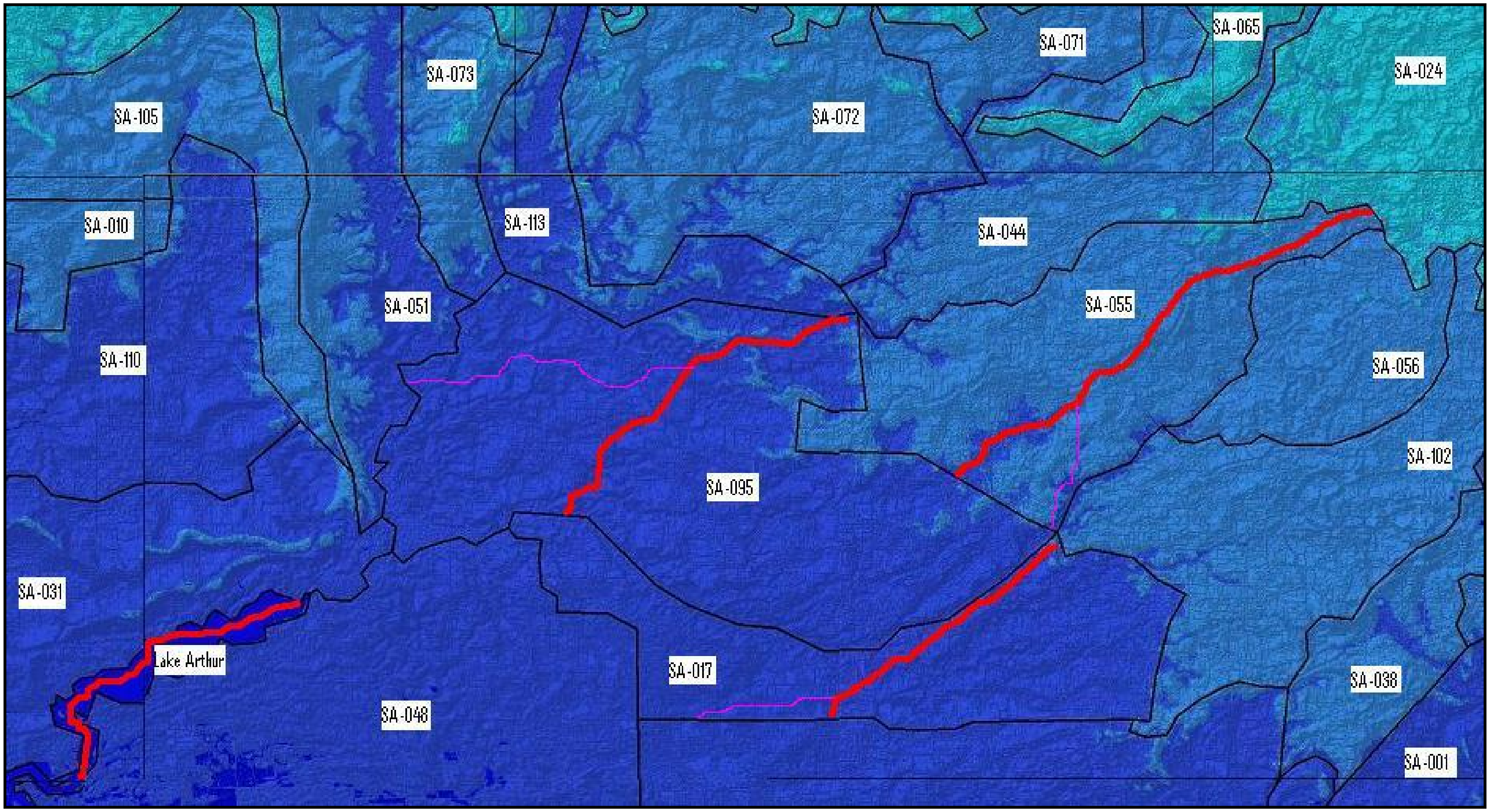

Figure L-4. Sample Drainage Paths Southeast of Jennings, LA

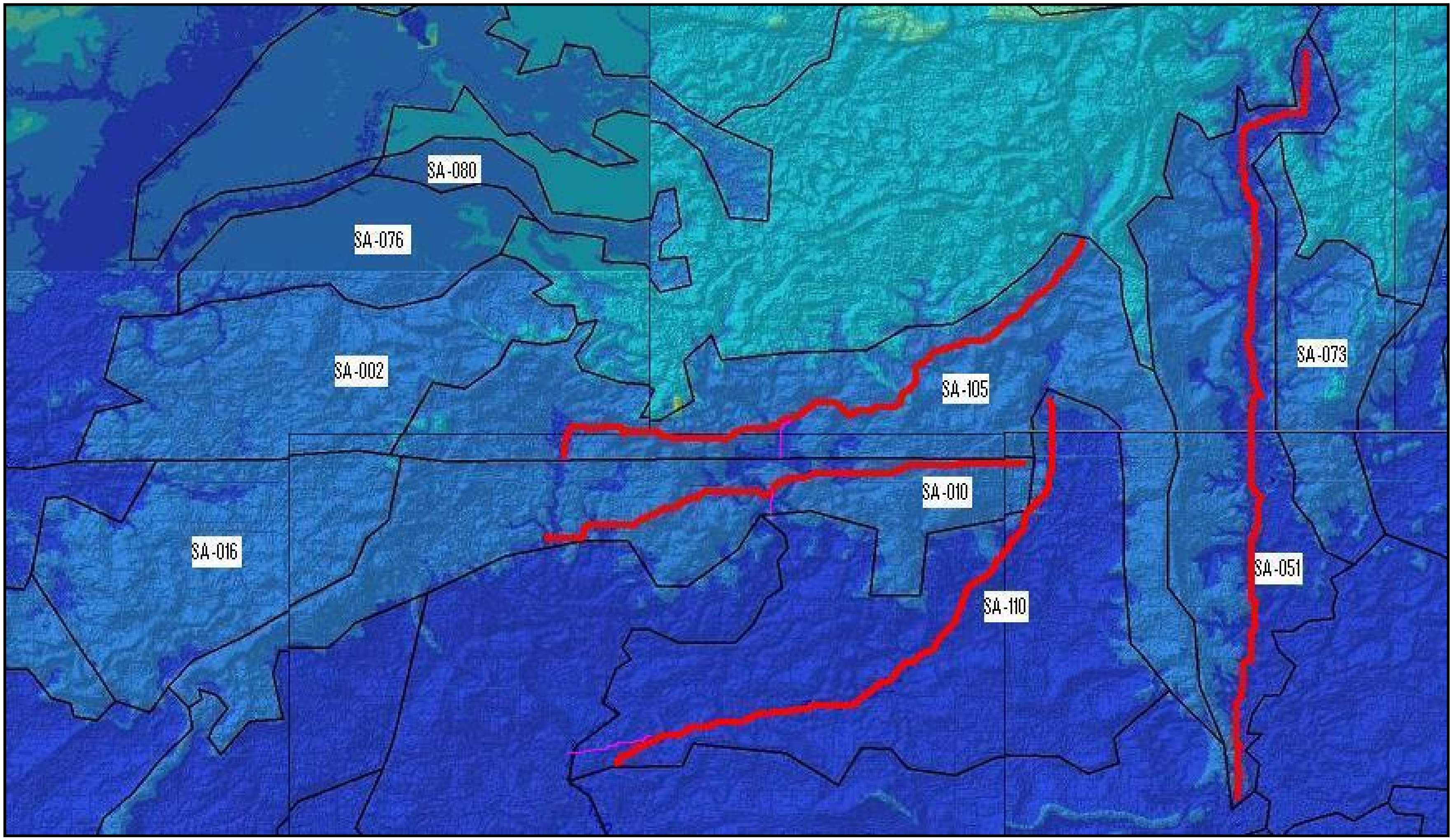

Figure L-5. Sample Drainage Paths West of Jennings, LA

IV. HYDROLOGIC MODELING

A. General. The hydrology and hydraulics was first calibrated to the rainfall event from November 5, 2002. This event was chosen based upon the simplest one-day runoff hydrograph that ended a wet period and was followed by a dry period, which guaranteed a successful calibration. The data from which this event was chosen was compiled from Corps website data from all four lock structures. The final candidates were also used to choose the verification event in 2001. More detail was required for the actual rainfall isohyetals, which was obtained from numerous rainfall stations available in NCDC publications. Once this was accomplished, water surface elevations were obtained for base conditions for nine synthetic rain fall events based upon the NWS TP-40 publication.

B. Rainfall. A summary report was compiled long after the rainfall event of November 5, 2002 by the Corps' Hydraulic Engineer. Rainfall data from the website www.ncdc.com was used to create more detailed rainfall isohyetals, which eventually led to the calculation of exact rainfall totals for each storage area's centroid.

C. Methodology. Lines were drawn between all known rainfall station totals and rainfall amounts in half-inch increments were marked on each line. All of the same numbered amounts were then connected, which yielded the first group of isohyetals of equal rainfall. It was actually easier to accomplish this with a spreadsheet and its plotting capabilities than by using GIS. Table L-6 lists the rainfall stations used.

Table L-6. Rainfall Stations Used

	*******November 2002******					
Location	**3**	**4**	**5**	**6**	**X-Longitude**	**Y-Latitude**
Hackberry 8 SSW	0.12	0.17	**4.84**	0.16	-93.40000	29.88333
Calcasieu Lock	0.23	0.37	4.40	0.00	-93.28333	30.08333
Bell City 13 SW	0.00	0.23	4.22	0.07	-93.08333	29.96667
Catfish Point Lock	0.03	0.10	3.39	0.00	-92.85000	29.86667
Jennings	0.14	0.47	3.86	0.00	-92.66667	30.20000
Eunice	0.19	1.34	3.36	0.03	-92.43333	30.50000
Ville Platte	0.45	2.00	3.57	0.02	-92.28333	30.70000
Grand Coteau	0.48	0.16	2.20	0.00	-92.03333	30.41667
Bunkie	0.48	3.68	2.37	0.00	-92.18333	30.96667
Oakdale	0.43	4.13	2.63	0.00	-92.66667	30.81667
Dry Creek 7 NW	0.42	4.90	2.53	0.00	-93.11667	30.73333
Vinton	0.37	1.17	2.50	0.01	-93.58333	30.20000
Freshwater Bayou Lock	0.07	0.00	0.90	0.94	-92.30000	29.55000
Schooner Bayou Lock	0.10	0.13	1.55	1.04	-92.26667	29.76667
Abbeville	0.01	0.95	1.34	0.61	-92.11667	29.96667
New Iberia	0.05	0.57	0.17	1.97	-91.78333	29.98333

The centroid of each area was calculated with GIS software, and the exact rainfall amount was linear interpolated between isohyetals for each of these points. The daily data from NCDC for the 4.84 inch maximum total was used to create the base rainfall curve, since this station also had the most reliable data. All exact rainfall amounts for each storage area centroid were then rounded to the nearest tenth of an inch of rainfall, and a multiplier was used to create that rainfall curve from the base 4.84 inches rainfall curve to match each storage area. These 8 rainfall curves ranged from 1.0 inches to 4.5 inches, and were all entered into the HEC-HMS software to produce exact runoff hydrographs for each storage area for November 5, 2002. This proved to be highly effective and made the hydraulic calibrations much easier. A map of the exact rainfall calculations, the rainfall isohyetals, and the extrapolated rainfall isohyetals is shown in figure L-6. Centroids are denoted by all of the unconnected dots.

The stations used for the verification event of 2001 are shown in table L-7. Plots for the verification event are shown in figures L-7 and L-8.

Table L-7. Stations Used to Verify Event of 2001

Station	Easting - X	Northing - Y	Rainfall (10 days)
Calcasieu Lock	2664142.648	581043.845	16.69
Hackberry 8 SSW	2625937.703	508970.215	11.97
Jennings	2859645.568	620676.385	10.04
Bell City 13 SW	2726739.997	537602.721	9.62
Eunice	2934400.198	728995.112	9.25
Catfish Point Lock	2800132.234	500187.129	9.08
Abbeville	3032801.364	534219.371	8.29
Ville Platte	2982243.123	801312.994	8.23
Oakdale	2862255.272	844947.550	7.92
Dry Creek 7 NW	2720523.741	816558.486	7.85
Oberlin Fire Tower	2829877.815	766523.603	7.76
Schooner Bayou Lock	2984714.653	461846.511	7.73
Grand Coteau	3060189.113	697699.248	7.41
Vinton	2570111.442	625203.805	6.95
Bunkie	3014392.695	898063.739	6.63
Freshwater Bayou Lock	2973475.650	383145.104	4.85
New Iberia	3138371.594	539709.890	4.54

Synthetic rainfall from the NWS-TP40 publication was used for nine events for the calibrated base conditions, as tabulated in table L-8.

The 10-year and 100-year rainfall events for base conditions were plotted for the entire study area by using GIS software, which is shown in figure L-9. The 10-year event clearly has the most effect, with the 100-year event adding only slightly more peak runoff. These peak stages are actually the results from HEC-RAS, the hydraulics portion of the study.

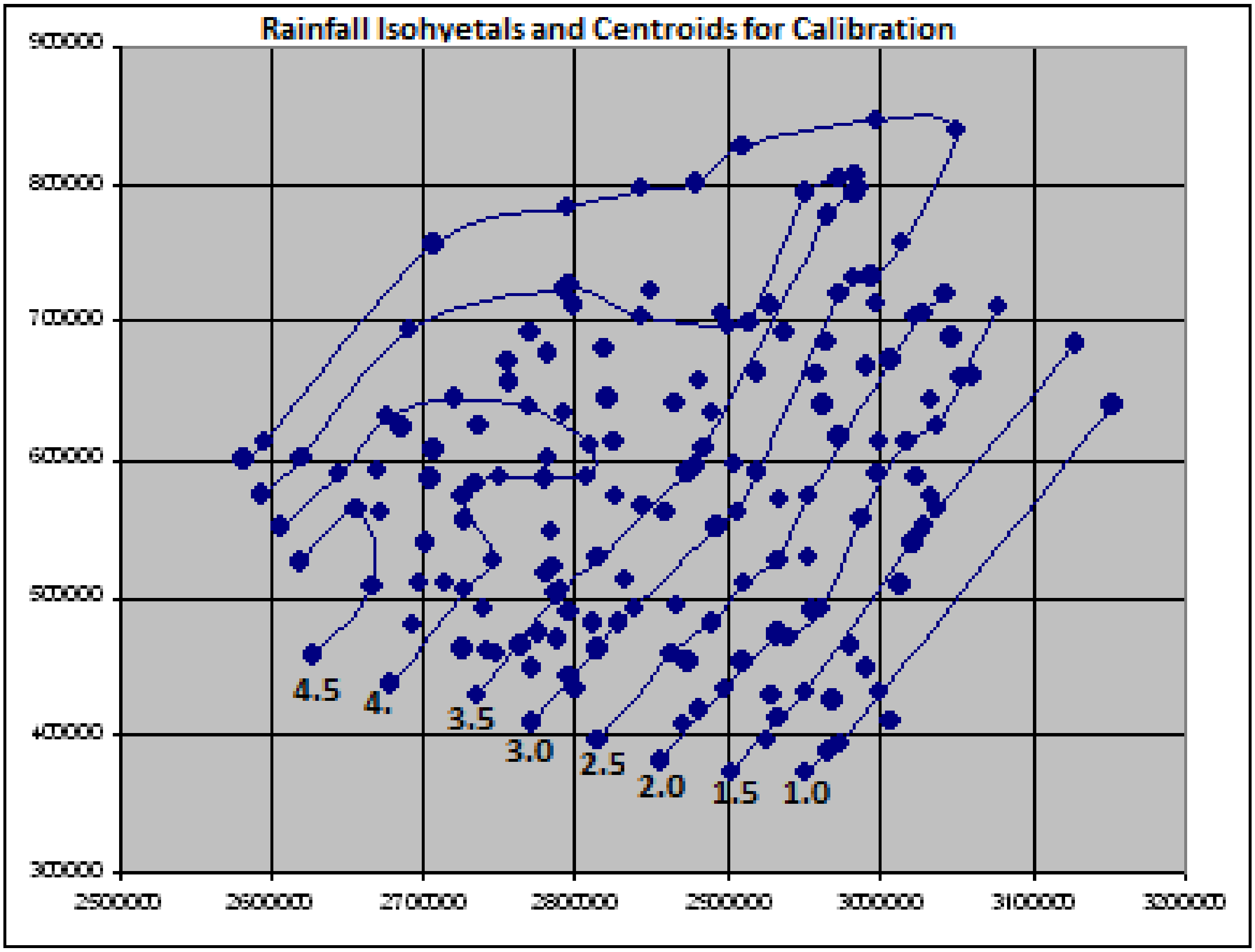

Figure L-6. Rainfall Isohyetals and Storage Area Centroids for Calibration

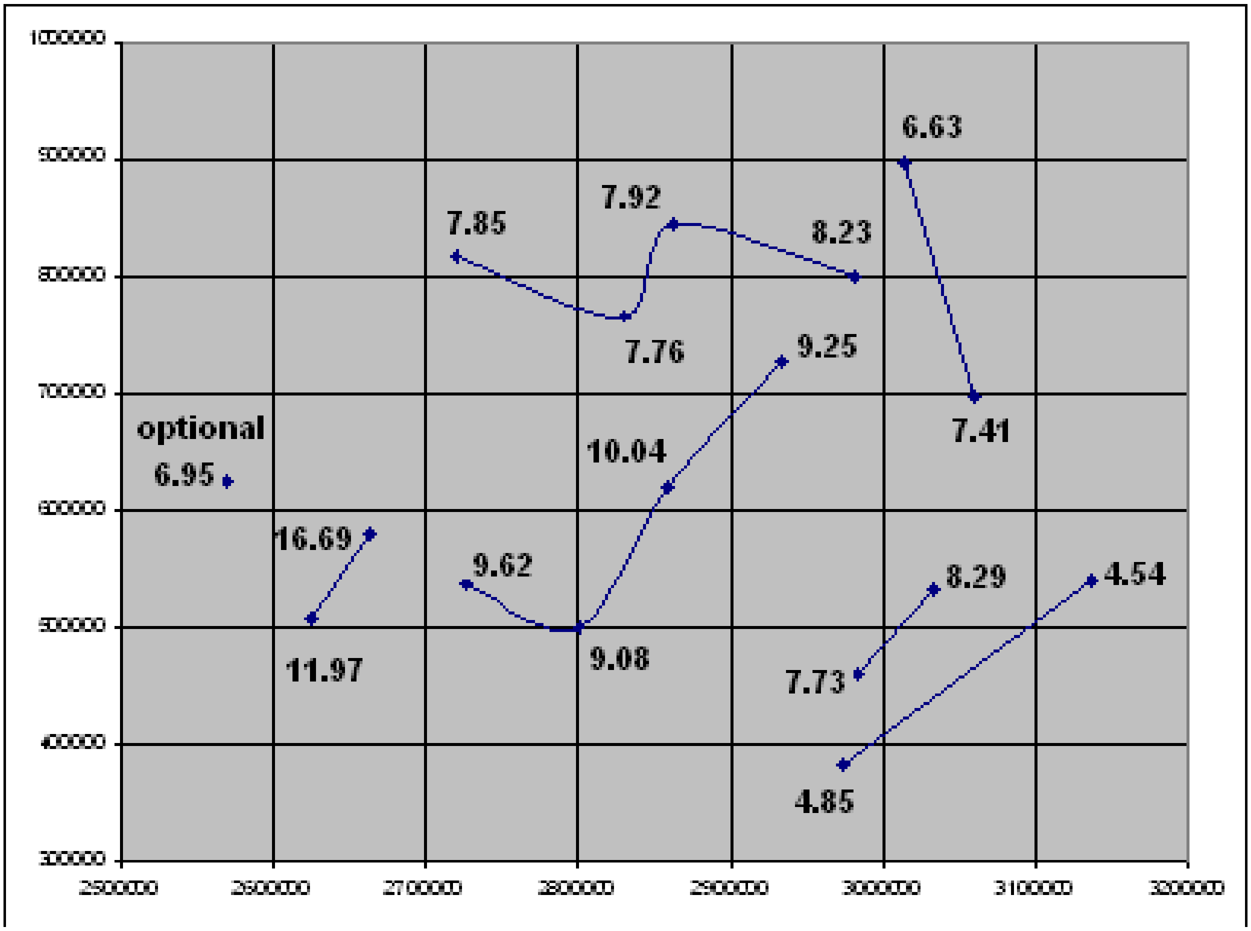

Figure L-7. Actual Rainfall Totals for Aug 28-Sept 6, 2001 in SW Louisiana

Table L-8. Probabilities for Calcasieu Parish Rainfall in Inches

Elapsed Time	100.00%	50.00%	20.00%	10.00%	4.00%	2.00%	1.00%	0.40%	0.20%
15 min	1.07	1.25	1.41	1.57	1.73	1.89	2.05	2.18	2.32
1 hour	2.10	2.45	2.90	3.35	3.80	4.25	4.75	5.13	5.52
2 hours	2.70	3.15	3.80	4.45	5.05	5.60	6.20	6.71	7.22
3 hours	2.90	3.50	4.30	5.00	5.70	6.40	7.25	7.88	8.50
6 hours	3.50	4.25	5.30	6.25	7.20	8.10	9.00	9.79	10.58
12 hours	4.10	5.10	6.50	7.60	9.00	10.00	11.00	11.98	12.97
24 hours	4.80	6.00	7.60	9.20	10.80	12.10	13.50	14.75	16.00

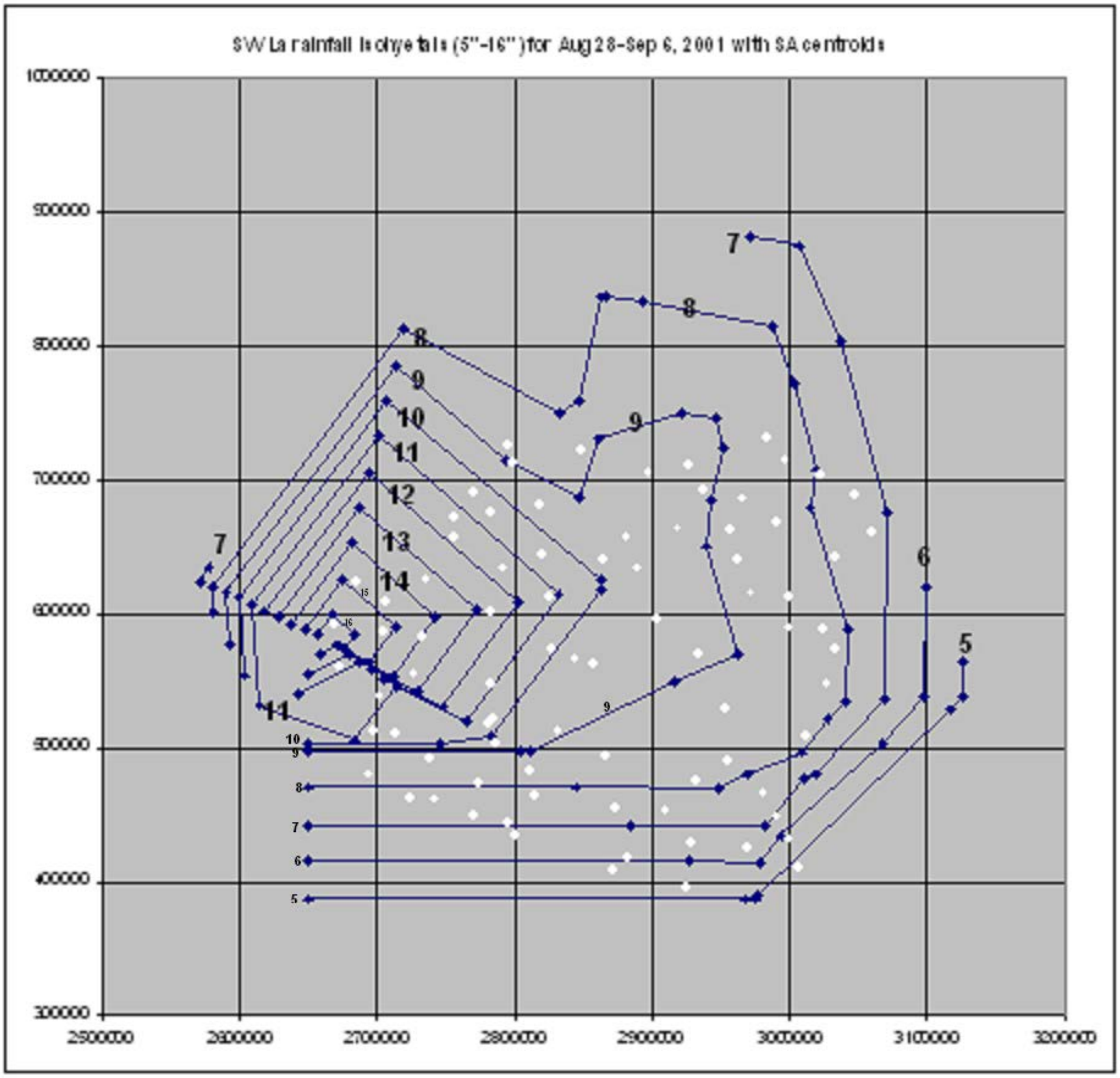

Figure L-8. Southwest Louisiana Rainfall Isohyetals for Aug 28 – Sept 6, 2001 with Storage Area Centroids Shown in White

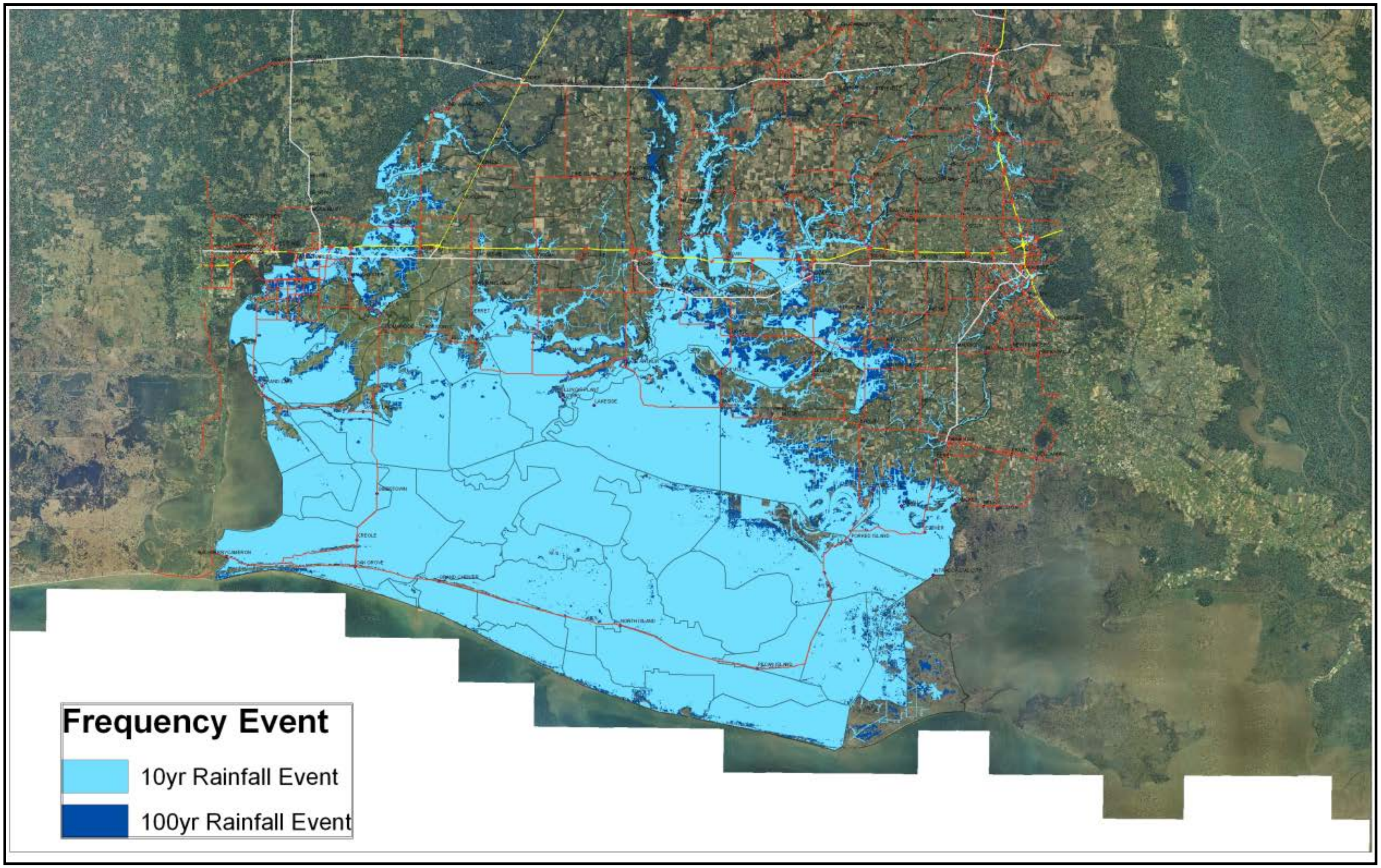

Figure L-9. Maximum Rainfall Inundation for 10-year and 100-year Events in Southwest Louisiana

V. HYDRAULIC MODELING

A. General. The watershed was modeled by focusing on three main components: geometry, hydrology, and boundary conditions. The geometry of the model describes the physical characteristics of the watershed including canals, storage areas, bridge crossings and locks. Subsurface drainage is best approximated by one artificial lateral weir per storage area, which drains into a canal or adjacent storage area at the lowest elevation on that storage area perimeter. Watershed hydrology describes the frequency, duration, and volume of storm water runoff as it travels from each storage area into the entry point at the storage area connection or lateral weir. Boundary conditions describe how the hydrographs are transported into and out of the watershed and between storage areas and canals.

Cross Section survey data from in-house sources was manually entered as flowing from upstream to downstream into HEC-RAS 4.0 River Analysis System software. Storage area boundaries and volume vs. elevation curves were also transported via spreadsheets from GIS software. To prevent the model from going unstable, very small pilot channels of negligible volume are usually added to each channel to prevent the model from running dry, but were never needed in this case.

B. Methodology. Having chosen November 5, 2002 as the most likely event to produce a successful calibration, it was simply a matter of looking up gage data for all four locks or structures and adjusting the readings for datum and subsidence. Once the rainfall runoff hydrographs for all areas was entered as inflow for each hydraulic storage area by the same name, it was a matter of adjusting the width of the few lateral weirs along the GIWW, which are located at the lowest elevation of each storage area. The model remained calibrated for 5 days after the actual event date, as shown in figure L-10.The model was actually test for a 21-day time period, but 5 days were sufficient for the initial calibration event.

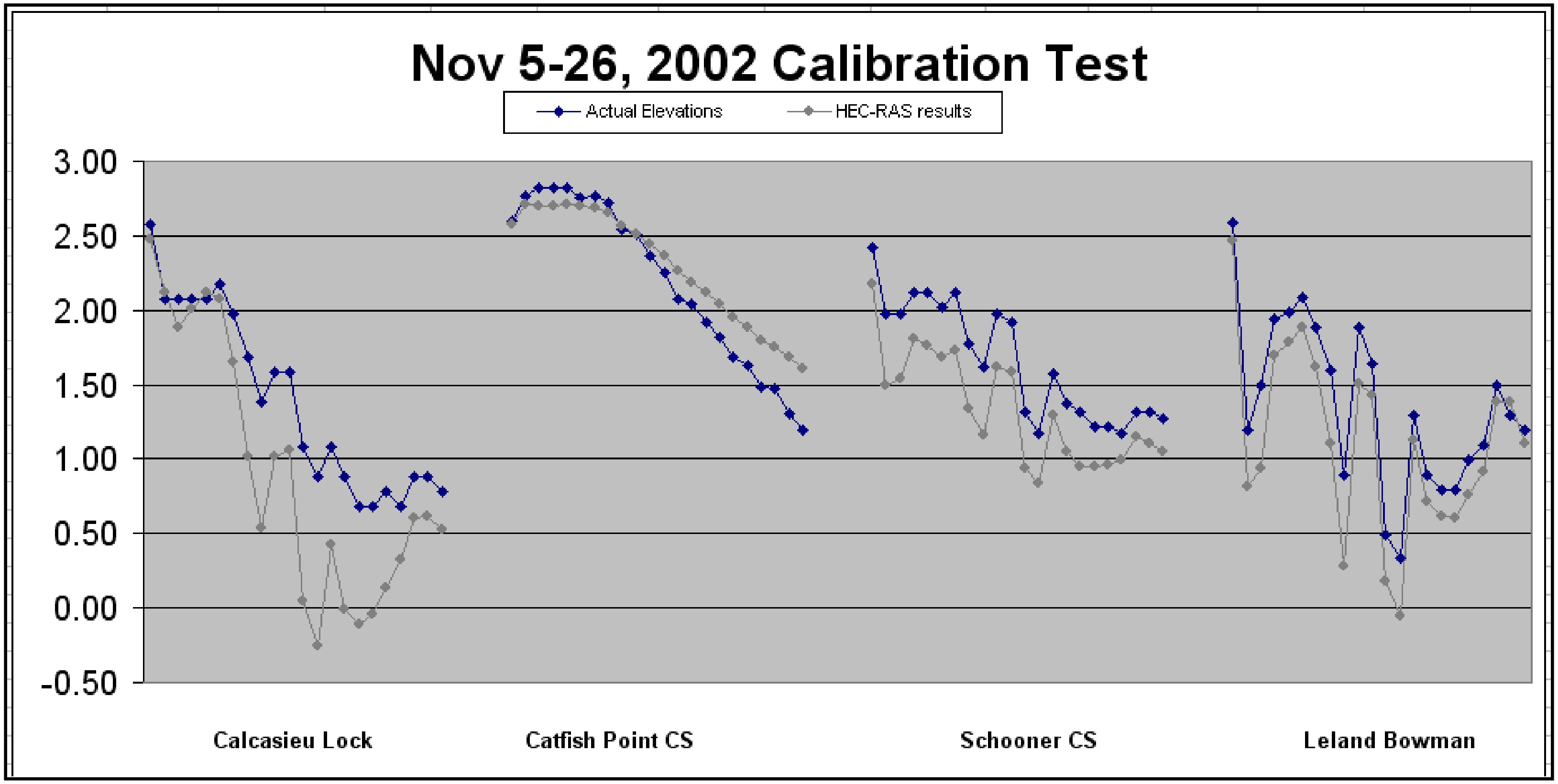

Figure L-10. November 5-26, 2002 Calibration Test

C. Geometry. Once the calibration was achieved, the geometry file and all hydrologic parameters were saved as a permanent record of base conditions. Runoff hydrographs from the nine synthetic rainfall events were then entered into HEC-RAS as input to this one calibrated geometry file. The results of maximum water surface elevations were then analyzed, but showed no lowering of peaks when test alternatives were run. This means that rainfall events govern due to the flat terrain in the southern part of the study, but drainage times are indeed affected either by sea level or lock openings. The initial elevations for each storage area are those that the HEC-RAS model requires to begin stable runs. They were derived from multiple HEC-RAS runs of the 1-year event, whereby the final elevation after many days should equal the starting elevation. From a hydraulic standpoint, this makes perfect sense, since a final elevation being higher than a starting elevation would mean that a particular storage area is experiencing long term ponding. The final elevation can never be lower than the starting elevation because the elevation of the lateral weir limits the drainage.

A backwater surface profile runs along the GIWW towards the east from the Calcasieu Lock, which is all the way to Bayou Lacassine and the Mermentau River at Lake Arthur. Since there is no protective dike on the north side of the GIWW, this backwater begins to flood the first two storage areas when the east gage at the lock reaches 2.95 feet or higher. The lock master had been using 3.00 feet as his cue to open up the gates before this model was even calibrated, so the model is in complete agreement with the actual results. The two storage areas are SA-030 and SA-106, which are outlined in yellow in the drainage sequence chart shown in figure L-11 (0, 18, 90, and 180 hours after the peaks). Since this is an extremely large amount of data for GIS to handle, only those storage areas that are affected by sea level rise or lock openings were plotted.

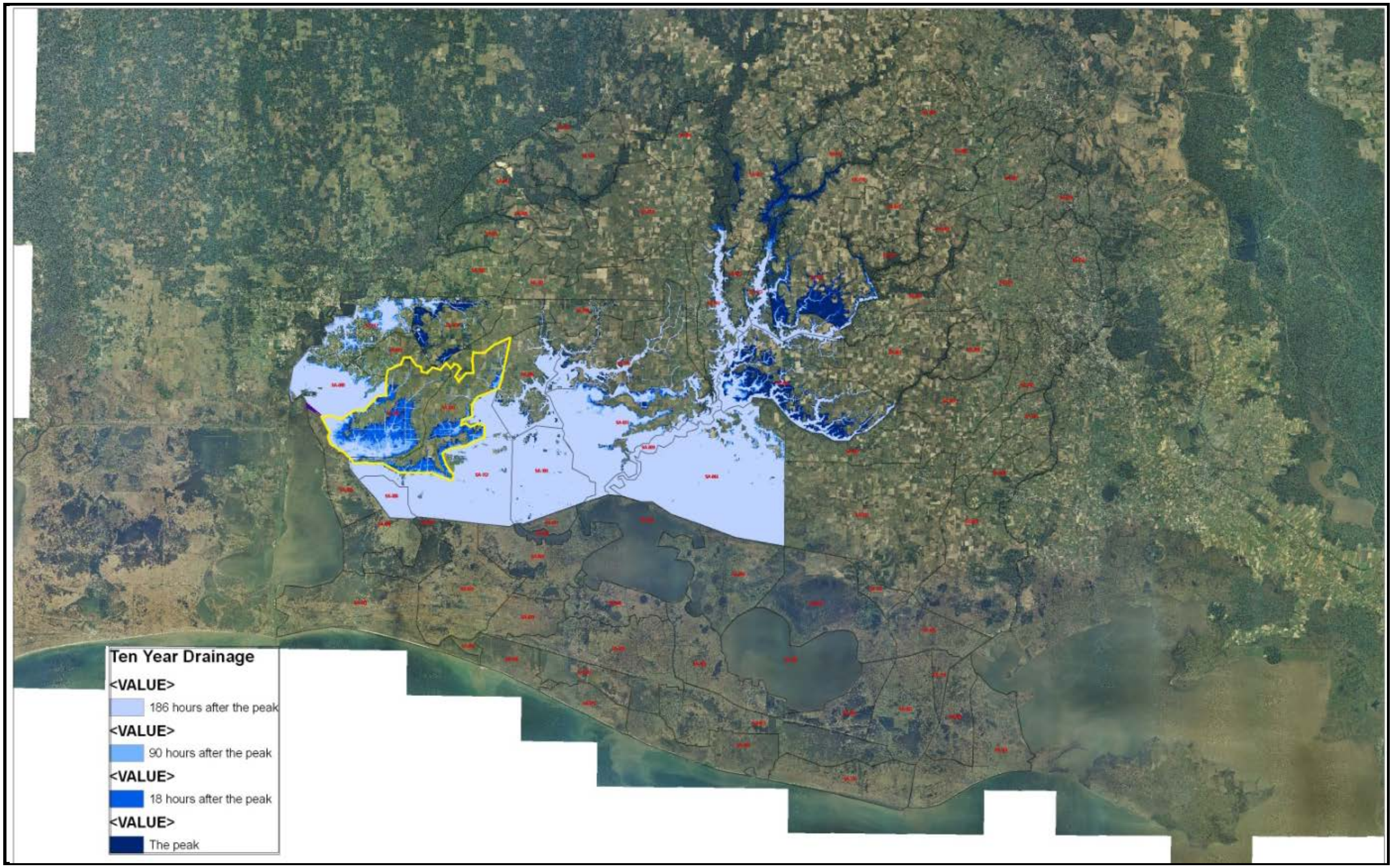

Figure L-11. Time Lapse of 10-year Rainfall Drainage in Problem Agricultural Area

D. Boundary Conditions. Since all flow was entered as one lateral inflow hydrograph for each storage area, a constant minimum flow of 10 cubic feet per second (cfs) was set for most channels to maintain stability of the HEC-RAS model. For the four locks or control structures, adjusted gulf stages were used for calibration purposes, while constant intermediate adjusted average stages were used for the all of the alternatives, which is 0.62 feet. In the case of Future without Project for the year 2070, (50 years after expected completion of construction), the intermediate sea level rise stage of 1. 70 feet was used at the Calcasieu Lock. Sea level rise for all four locks is shown in table L-9.

Table L-9. Relative Sea Level Rise for All Boundary Conditions

	Historic Rate	50 Year Relative Sea Level Rise Estimate				**Conctruction complete 2020**
	(mm/year)	Low (ft)	Intermediate (ft)	High (ft)	**Downstream B/C**	
Calcasieu Lock West	4.18	0.7	1.1	2.4	**1.7**	Calcasieu Lock West
Catfish Point South	7.04	1.2	1.6	2.9	**2.2**	Catfish Point South
Schooner Bayou East	5.70	0.9	1.3	2.6	**1.9**	Schooner Bayou East
Leland Bowman East	6.19	1.0	1.4	2.7	**2.0**	Leland Bowman East
		50 Year Estimated Stages				**Future w/o Project 2070**
		Low (ft)	Intermediate (ft)	High (ft)	**Downstream B/C**	
Calcasieu Lock West		2.7	3.1	4.4	**3.7**	Calcasieu Lock West
Catfish Point South		3.2	3.6	4.9	**4.2**	Catfish Point South
Schooner Bayou East		2.9	3.3	4.6	**3.9**	Schooner Bayou East
Leland Bowman East		3.0	3.4	4.7	**4.0**	Leland Bowman East

E. Roughness Coefficients. For roughness factors, Manning's "n" value was set to .09 for most channels and 0.10 for all overbanks for all conditions. Normally, a roughness of .045 would be assigned to channels, but these could only be used in a few of the smallest canals. The high channel roughness of 0.09 has already been justified in the calibration effort due to excessive debris in most of the channels. Since this project is composed primarily of storage areas, the coefficients for each connection were experimented with, but showed negligible results.

F. Drainage Criteria. Drainage of the entire basin can be improved by two means: lowering of sea level or adding another outlet such as a lock or gate.

Conversely, drainage is adversely affected by two means: increasing sea level or closing down the existing lock entirely. Ironically, a 50-year intermediate sea level rise will show less emptying and filling lock times due to less head differential because the remainder of the rise in stages winds up flooding the agricultural areas SA-030 and SA-106 even more. Applying these criteria of drainage to the possible alternatives, when given two channels, optimum drainage and improved locking times will happen when drainage is through the larger channel and locking is through the smaller channel. When the two channels are one and the same as for existing conditions, both drainage and locking times become less efficient.

G. Hydraulic Analysis. Since this is a navigation project and not a drainage project, the focus is not placed on water surface elevations for each of the 81 storage areas. Instead, the focus is how all of these storage areas drain into the GIWW and through the lock structures. The only way to improve navigation is to improve drainage; to do so, a gate or another lock could be constructed to add another larger channel adjacent to the existing lock. Lining the north side of the GIWW with a 4-foot high dike for about 33 miles upstream of the Calcasieu Lock would theoretically solve the flooding problems in these agricultural areas (with small pumps to drain over the dikes), but this is not part of the study and it is unknown what other areas would flood as a result.

VI. PLAN DESCRIPTION AND ANALYSIS

A. Description of Alternatives. Five alternatives were finally considered after trying many possible configurations, most of which showed no savings at all on locking times.

Improved locking times are also associated with improved drainage, even though this is not a drainage project.

Alternative 1 - A 75-foot sluice gate that is generally within the alignment of the previously proposed south lock. The outfall and intakes will need to be excavated with material being beneficially used for marsh creation. For safety, a guide wall extension or some other suitable structure to prevent barges from being affected by cross currents will need to be evaluated. Basically, rainfall runoff is causing large head differentials from the eastern side of the existing lock, which causes navigation delays. This proposed sluice gate on the south side of the existing lock would improve drainage and reduce navigation delays. To quantify this, third order polynomial equations were derived from a program used to compute emptying and filling times for a given size lock chamber. HEC-RAS was used to calculate upstream water surface elevations at any given time, with the downstream elevation being held to 0.62 feet. The difference between the two is the value known as lift that is needed for the third order polynomial equations. Comparing a 110-foot wide sluice gate and a 75-foot wide sluice gate to the existing conditions, the amount of minutes saved per locking time was computed and plotted for all nine rainfall events at hourly intervals for a period of 228 hours (figure L-12). In all cases, locking times are saved, but the larger 110-foot gate was not enough savings to justify the added cost. The equations used to compute filling and emptying times are:

110-foot Earthen chamber = -.0324*Lift^3+.4520*Lift^2+.4257*Lift+.0079
75-foot Earthen chamber = -.0083*Lift^3+.2286*Lift^2+.644*Lift+.0071

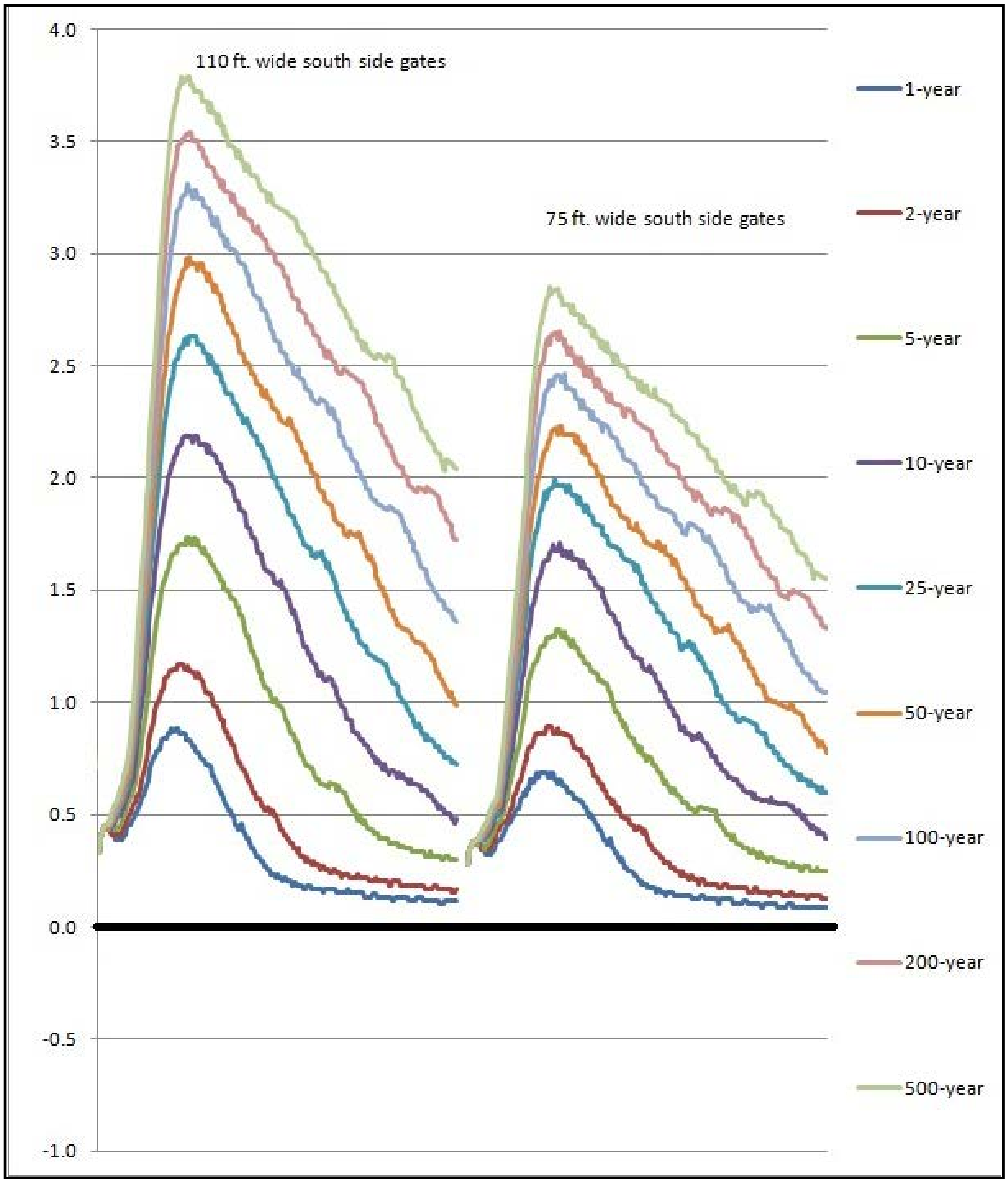

Figure L-12. Calcasieu Lock Study – Minutes Saved Per Locking
(Each line length represents 228 hours when compared to base location.)

For the remaining alternatives, various size pumps were placed at different locations and the 10-year rainfall event was run in HEC-RAS. Figures L-13 and L-14 show the results in the best possible way. Note that the second chart shows two different cross sections, with Black Bayou on the left and the GIWW on the right. The maximum size pump would clearly save locking times, but also introduce navigation hazards if placed where it is needed the most.

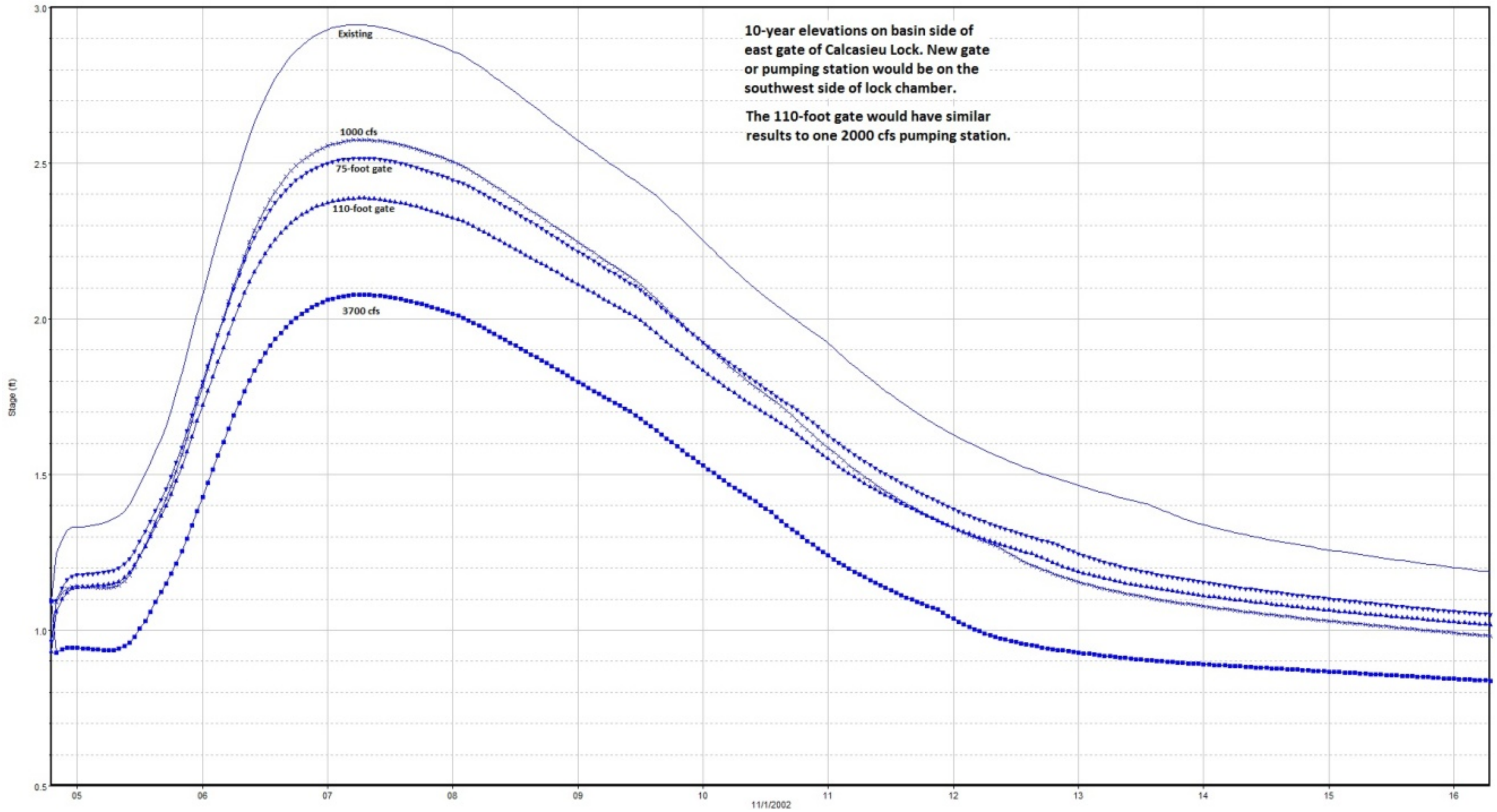

Figure L-13. 10-year Elevations at East Calcasieu Lock Gage for Alternatives and Existing Conditions

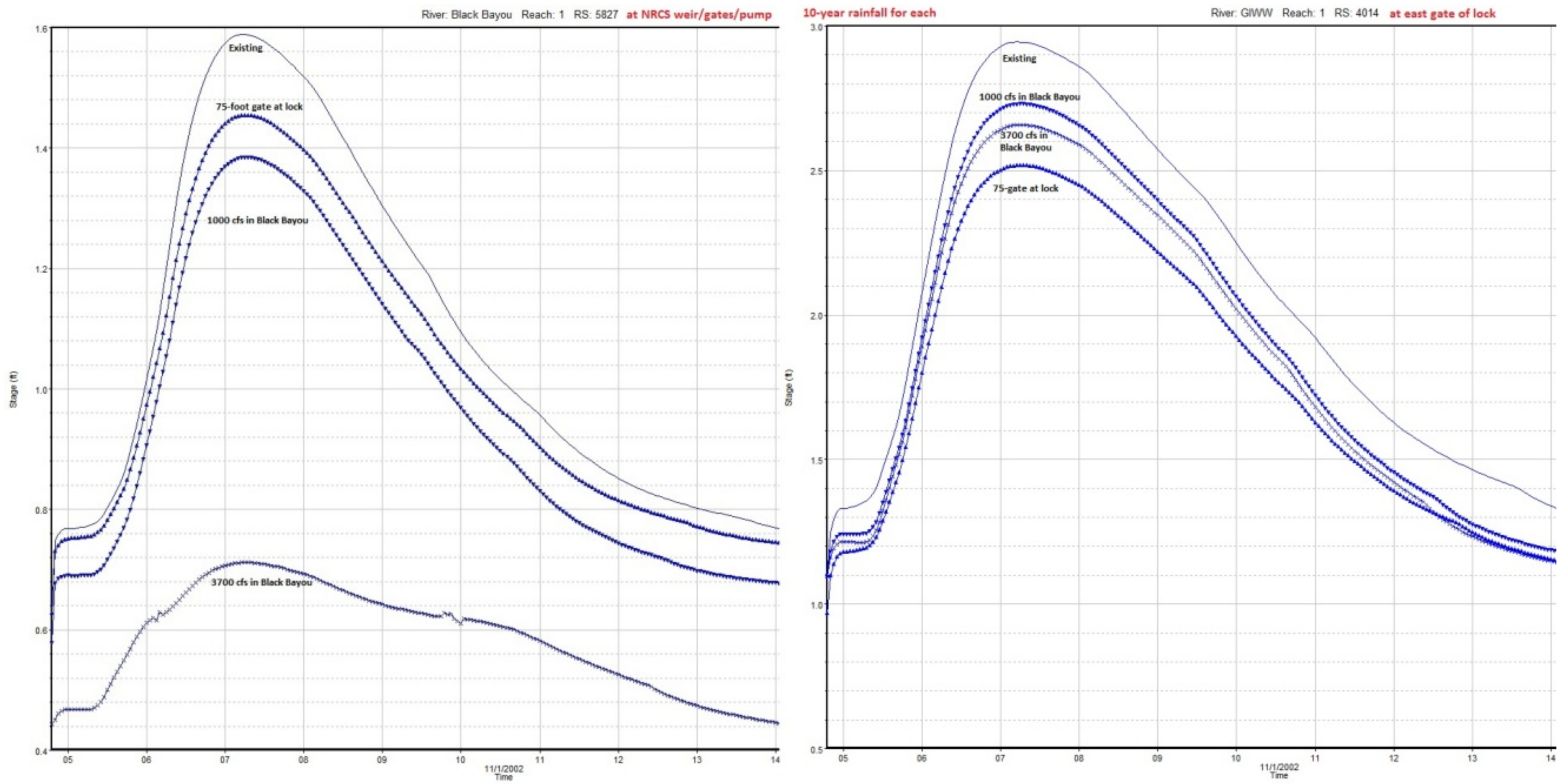

Figure L-14. 10-year Elevations at Black Bayou for Alternatives and Existing Conditions

Alternative 2 - A 3,700 cfs pumping station would be constructed generally within the alignment of the previously proposed south lock. The outfall will need to be excavated with material being beneficially used for marsh creation. For safety, a guide wall extension or some other suitable structure to prevent barges from being affected by cross currents will need to be evaluated. This pumping station was suggested by the Value Engineering team and was also the original suggestion from the Hydraulic Engineer for this project. However, due to the size of this pump, the cost would be prohibitive. The location of this pump also introduces a navigation hazard, and the pump may need to be turned off when locking through, which defeats the entire purpose of the pump.

Alternative 3 - Supplemental Culverts would be added to the Black Bayou NRCS structure to increase its capacity and operate in conjunctions with it. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 NAVD88. Black Bayou Dredging to the east and west of the NRCS structure will also occur. The existing NRCS gates on Black Bayou were never manually operated as intended, which has caused a siltation problem in the channel. The proposed weir is designed to the same elevation of +3.0 feet NAVD88 that signifies the lock master to open up the lock gates for drainage. This would allow rainfall runoff to drain over the weir while keeping gulf stages from entering the freshwater area. When the gulf side reaches +2.0 NAVD88, the lock remains closed to prevent salt water intrusion.

Alternative 4 - A 2,000 cfs Pumping Station would be constructed adjacent and north of the existing Black Bayou NRCS structure and operate in conjunction with it. The pump would likely be west of the road with pipes running under the roadway. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 NAVD88**.** Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative operates in conjunction with the Black Bayou structure. This will require the Corps to take over Operation and Maintenance, Repair, Replacement and Rehabilitation of the structure once its 20 project life under the Coastal Wetlands Protection & Restoration Act ends.[1]

Alternative 5 - A 3,700 cfs Pumping Station would be constructed adjacent and north of the existing Black Bayou NRCS structure. The pump would likely be west of the road with pipes running under the roadway. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 NAVD88. Black Bayou Dredging to the east and west of the NRCS structure will also occur. This alternative operates independent of the Black Bayou Structure. The pumping station location is also too far away from the existing lock to be beneficial to drainage.

B. Future Without Project. Theoretically, the Future Without Project option would show improved locking times due to reduced head differentials, but this would be at the expense of induced damages in the two problematic agricultural areas of SA-030 and SA-106.

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[1] Following IPR#1 in February 2013 it was determined that a 1,000 cfs pump would be insufficient to overcome the natural tendency to drain through the lock when the sector gates were open. Additional H&H analysis indicated that a 2,000 cfs pump operating in conjunction with the Black Bayou structure would be sufficient to provide the drainage capacity the lock currently provides. Alternative 4 basically adds a 2000 cfs pump to Alternative 2, working in conjunction with the proposed weir in Black Bayou. Initially, this pump was proposed to be placed near the existing NRCS gates, which was too far away to be beneficial to drainage. However, if the pump is moved closer to the GIWW, then drainage could be improved, but with a navigation hazard being added.

This has already been tested to find the results. If a 4-foot high dike were to be constructed on the north side of the GIWW next to these two areas to prevent induced damages, the excess water that would have flooded these areas would return to the GIWW and increase head differentials, thereby negating any improved locking times. This was not actually tested, since it was not part of the Scope of Work, however these results can be expected. Also, the Future Without Project is based solely upon 50-year projected intermediate sea level rise, which may not even happen.

As for the possibility of widening the existing lock, this is not feasible due to the fact that the lock cannot be shut down for any extended length of time, which would happen if this were to be constructed.

VII. RISK AND UNCERTAINTY

A. Introduction. This section addresses the hydrologic and hydraulic engineering portion of the risk and uncertainty analysis of the Calcasieu Lock Study as required under ER 1105-2-100 and ER 11105-2-101. Also the risk-based analysis performed follows the guidelines of Engineering Circular (EC) 1105-2-205.

The objective of this interdisciplinary approach is to conduct a probabilistic analysis of all key variables, parameters and components of flood damage reduction studies. Key economic variables in an urban situation normally include depth-damage curves, structure values, content values, structure first-floor elevations, structure types, flood warning times and flood evacuation effectiveness. Furthermore, the hydrologic and hydraulic variables such as discharge and stage are included in the frequency analysis.

B. Methodology. The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) numerical model developed by the U.S. Army Corps of Engineers' Hydrologic Engineering Center was used to perform the analysis. The HEC-FDA model provides the capability to perform an integrated hydrologic engineering and economic analysis during the formulation and evaluation of flood damage reduction plans. The model includes risk analysis methods to quantify uncertainty in discharge-exceedance probability, stage-discharge, and stage-damage functions and incorporate it into the economic and engineering performance analysis of alternatives. The program applies Monte Carlo simulation, a numerical analysis procedure that computes the expected value of damage while explicitly accounting for the uncertainty in the basic value to perform the computations. The individual plans and/or plan comparisons' evaluation is accomplished with the simulation's output reports.

Sufficient or appropriate stage gage observations are ideal to develop the frequency curves. Since this data is not available in this sub-basin, rainfall-runoff analysis is used to develop a synthetic frequency curve. The synthetic frequency curve or graphical stage-probability function was determined by using the Graphical Exceedance Probability Method. However, this method requires an estimate of the equivalent years of record. The equivalent years of record was estimated using the guidelines established in Engineer Technical Letter **(**ETL) 1110-2-537, *Engineering and Design Uncertainty Estimates for Non-analytical Frequency Curve*, 31 October 1997 and EC 1105-2-205, *Risk-Based Analysis for Evaluation of Hydrology/Hydraulics and Economics in Flood Damage Reduction Studies*, 25 February 1994. In addition, the magnitude of uncertainty related to the graphical stage-probability function is estimated with the order statistics methodology.

C. Application. The synthetic rainfall data used to develop the hydrologic and hydraulic analysis was obtained from the NWS TP No. 40.The NWS's network of rainfall stations includes three stations in the New Orleans Metropolitan Area. These stations are located at Audubon Park, Armstrong International Airport, and the New Orleans Airport with a rainfall record from 1961 to 1990, for a total of 29 years.

The NWS rainfall period of record and the guidelines as set forth in ETL 1110-2-537 and EC 1105-2-205 were used to determine the equivalent record length of 50 years. In addition, the synthetic stage-frequency coordinates for each storage area within the basin were input to develop its stage-probability function and confidence limits.

VIII. REFERENCES

HEC – Documentation for software from HEC-HMS, HEC-RAS, and HEC-FDA

SCS. Hydrology SCS National Engineering Handbook. Soil Conservation Service U.S. Department of Agriculture 1972

SURVEYS

I. GENERAL

In an effort to provide quantities for the Calcasieu Lock Feasibility Study, survey data for this project was gathered at the area surrounding the lock. The work was broken into two distinct areas: (1) surveys of the proposed culvert structure site and (2) hydro-surveys of the approach channels.

The delivery order for the surveys consisted of collecting data in the form of cross sections utilizing Real Time Kinematic GPS and single beam hydrographic survey techniques. A GPS network was performed to establish horizontal and vertical control to provided control values in the 2006.81 epoch.

II. BACKGROUND

The survey consisted of collecting 33 cross sections in three data sets. Specific line files were provided and named. In addition to the sections, a GPS network was established to orient control to the 2006.81 epoch. All of the coordinates shown and data computed are referenced to the North American Datum of 1983 (NAD83) and are using State Plane Coordinates for the Louisiana South Zone (1702) in U. S. Survey Feet 2006.81 epoch. The locations of the cross sections and selected elevations are shown in figure L-15.

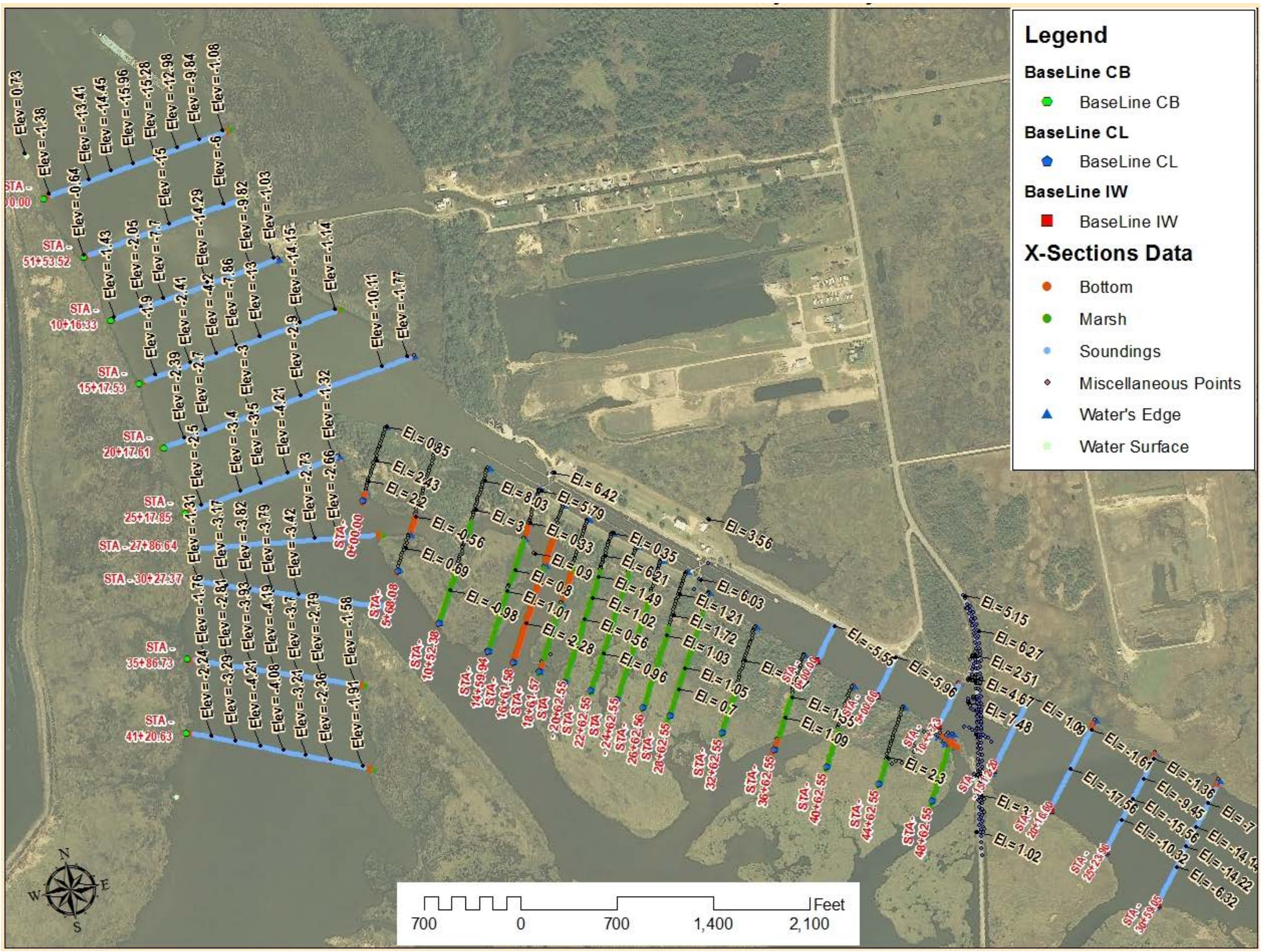

Figure L-15. Cross Sections and Elevations

GEOTECHNICAL

I. GENERAL

The preferred alternative chosen for this project is Alternative #1, an 82-foot wide and 100-foot long culvert that consists of five 9-foot x 14-foot openings, located within the alignment of the previously proposed south lock. Borings CLR-3U and CLR-4U were taken at the location of the culvert structure. Geotechnical investigations in this report are for preliminary purposes only. Additional borings may be required for pile design, and settlement analysis of the structure. Additional borings will also be required along the outfall and intake channel. These channels will require excavation, and require stability analysis for slope design of dredge cuts along the channel, and for the prevention of scour. Design of a temporary retaining structure used for construction is also anticipated as part of engineering design. The TRS will be a braced sheetpile structure, therefore no berms are required. Seepage cutoff using sheetpile will be driven for the temporary retaining structure, and sheetpile seepage cutoff will be driven under the culvert. The channel will be dug using a cutterhead dredge.

II. FIELD INVESTIGATIONS

Two undisturbed borings (CLR-3U and CLR-4U) were taken in October 2012 at the location of the Calcasieu Lock project. The borings were drilled to approximately 150 feet in depth. Individual graphic logs of the soil borings are presented in figures L-17 & L-18 along with a soil boring legend. Boring locations are shown in figure L-16. Additional borings will be required for pile design, settlement analysis of the structure, stability analysis of the channel, and for the prevention of scour.

III. LABORATORY TESTS

Visual classifications and water content determinations were provided for all cohesive samples from the borings. Unconsolidated undrained (Q) Triaxial tests were provided for selected samples. Consolidation and specific gravity determinations tests were provided for selected samples. Atterberg limit determinations were provided for strength test and consolidation test specimen.

IV. SITE GEOLOGY

The project area is located southwest of the Calcasieu Lock in Calcasieu Parish, La. Natural ground elevations are between 0 and (+) 5 feet NAVD[2]. Dominant physiographic features in the area consist of Calcasieu Lake, Intracoastal Waterway, Pleistocene Terrace, Calcasieu River and its associated natural levees, swamp, and marsh. The surface at boring CLR-3U is composed of fill material approximately 4 feet thick overlying swamp deposits consisting predominantly of organic and fat clays with wood. Pleistocene deposits composed of stiff to very stiff oxidized clays interbedded with layers and lenses of silts and sands comprise most of the surface in the project area. The top of the Pleistocene surface is approximately +6 feet in elevation and extends to at least -140 feet.

Groundwater is at or near the surface. The silts and silty sands within the Pleistocene deposits may be hydraulically connected to the Calcasieu River and the GIWW.

V. PILE CAPACITIES

[2] All elevations in NAVD 88

As requested by Structures Branch to assist them in their estimates for design of the pile foundation of the Calcasieu Lock structure. Preliminary Pile Capacity Curves were developed for 12-inch Concrete, 14-inch Concrete, 18-inch pipe, HP 12x53 steel, and HP14x73 steel piles using a program that was created by the New Orleans District USACE. These Pile Capacity Curves can be seen in figures L-20 thru L-24. With minor thickness of overlying soft organic/plastic clays, potential for downdrag is expected to be negligible.

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Figure L-16. Boring Location Map

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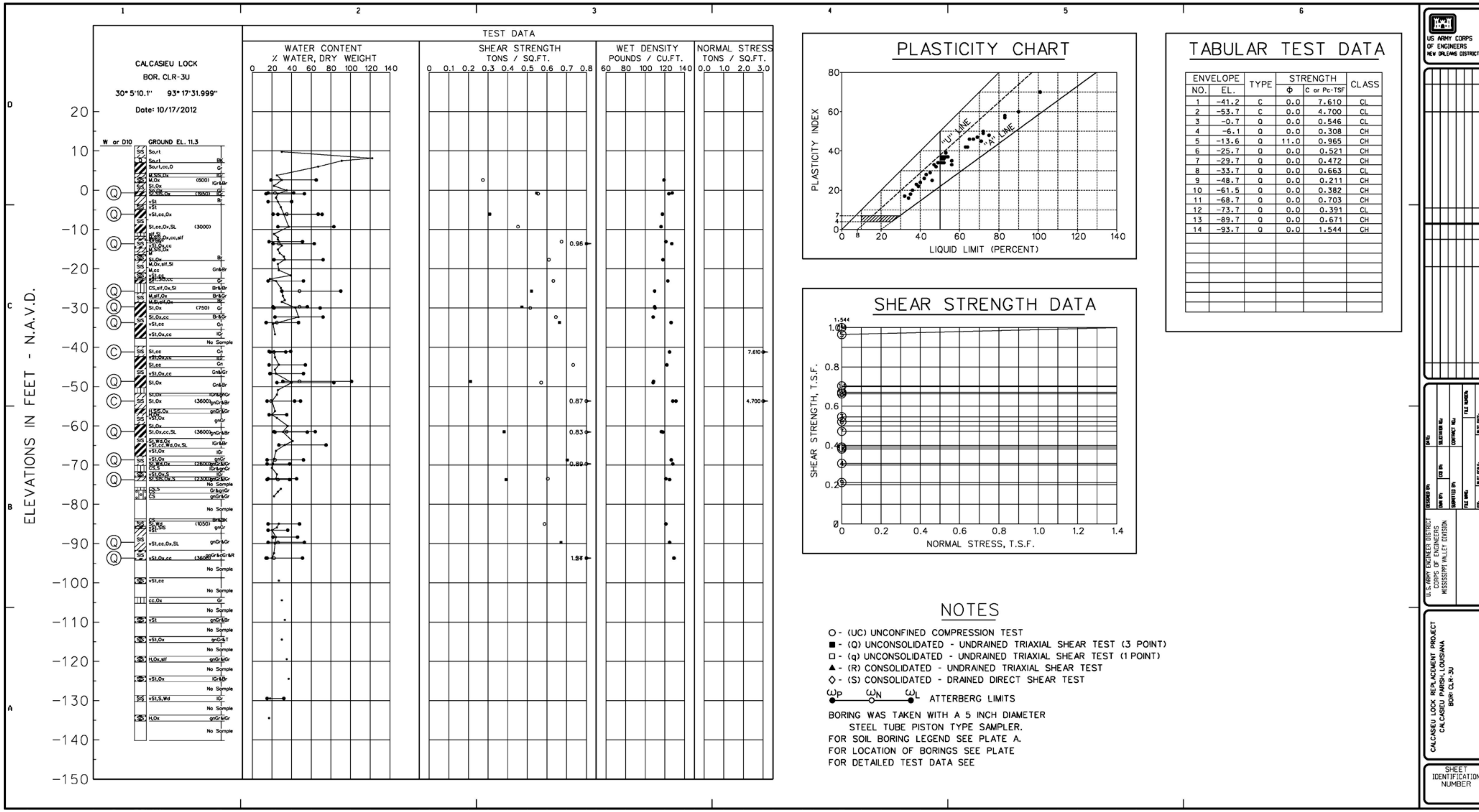

TABULAR TEST DATA

ENVELOPE		TYPE	STRENGTH		CLASS
NO.	EL.		Φ	C or Pc-TSF	
1	-41.2	C	0.0	7.610	CL
2	-53.7	C	0.0	4.700	CL
3	-0.7	Q	0.0	0.546	CL
4	-6.1	Q	0.0	0.308	CH
5	-13.6	Q	11.0	0.965	CH
6	-25.7	Q	0.0	0.521	CH
7	-29.7	Q	0.0	0.472	CH
8	-33.7	Q	0.0	0.663	CL
9	-48.7	Q	0.0	0.211	CH
10	-61.5	Q	0.0	0.382	CH
11	-68.7	Q	0.0	0.703	CH
12	-73.7	Q	0.0	0.391	CL
13	-89.7	Q	0.0	0.671	CH
14	-93.7	Q	0.0	1.544	CH

Figure L-17. CLR-3U Test Results

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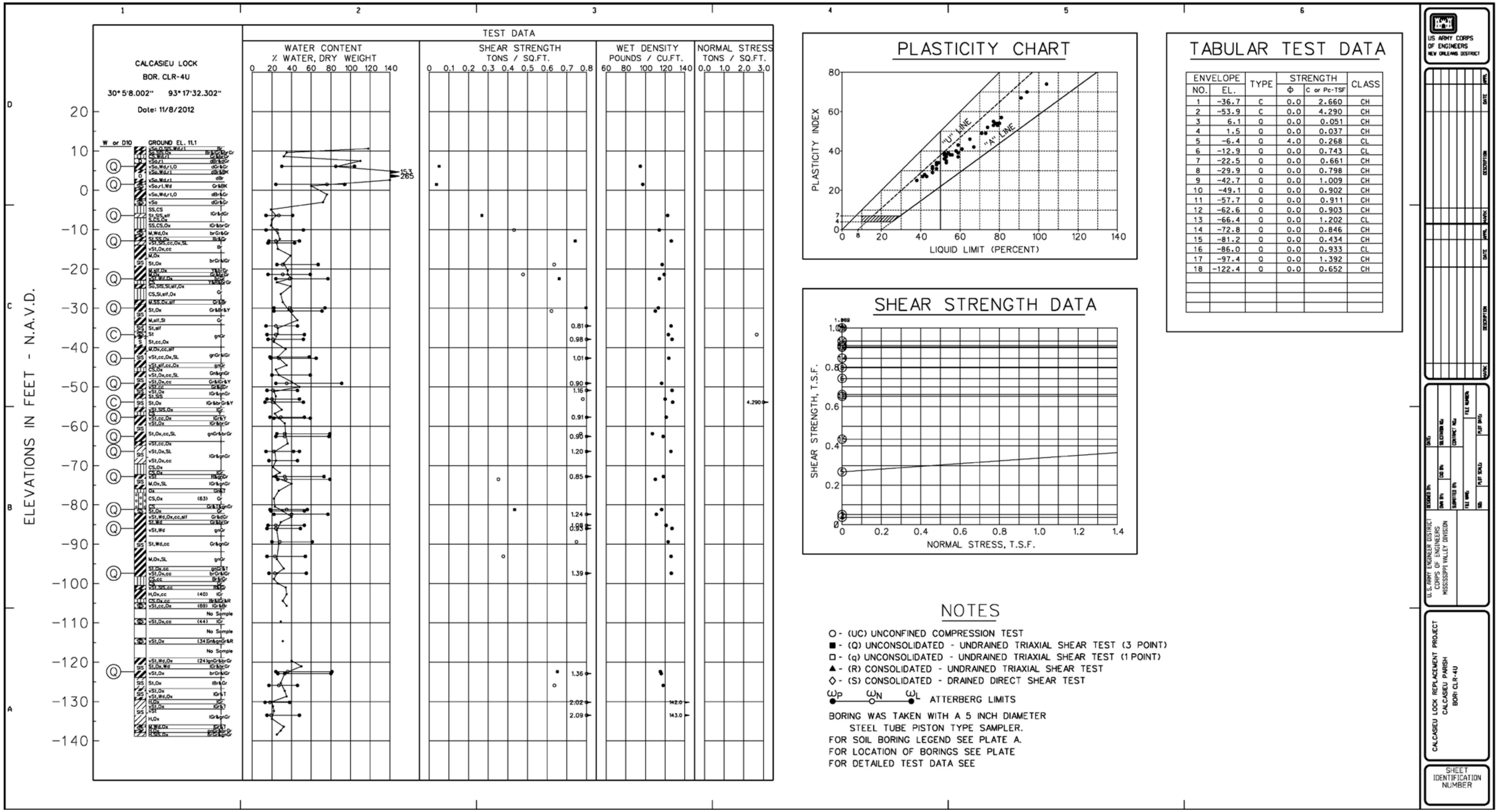

ENVELOPE NO.	EL.	TYPE	STRENGTH Φ	C or Pc-TSF	CLASS
1	-36.7	C	0.0	2.660	CH
2	-53.9	C	0.0	4.290	CH
3	6.1	Q	0.0	0.051	CH
4	1.5	Q	0.0	0.037	CH
5	-6.4	Q	4.0	0.268	CL
6	-12.9	Q	0.0	0.743	CL
7	-22.5	Q	0.0	0.661	CH
8	-29.9	Q	0.0	0.798	CH
9	-42.7	Q	0.0	1.009	CH
10	-49.1	Q	0.0	0.902	CH
11	-57.7	Q	0.0	0.911	CH
12	-62.6	Q	0.0	0.903	CH
13	-66.4	Q	0.0	1.202	CL
14	-72.8	Q	0.0	0.846	CH
15	-81.2	Q	0.0	0.434	CH
16	-86.0	Q	0.0	0.933	CL
17	-97.4	Q	0.0	1.392	CH
18	-122.4	Q	0.0	0.652	CH

Figure L-18. CLR-4U Tests Results

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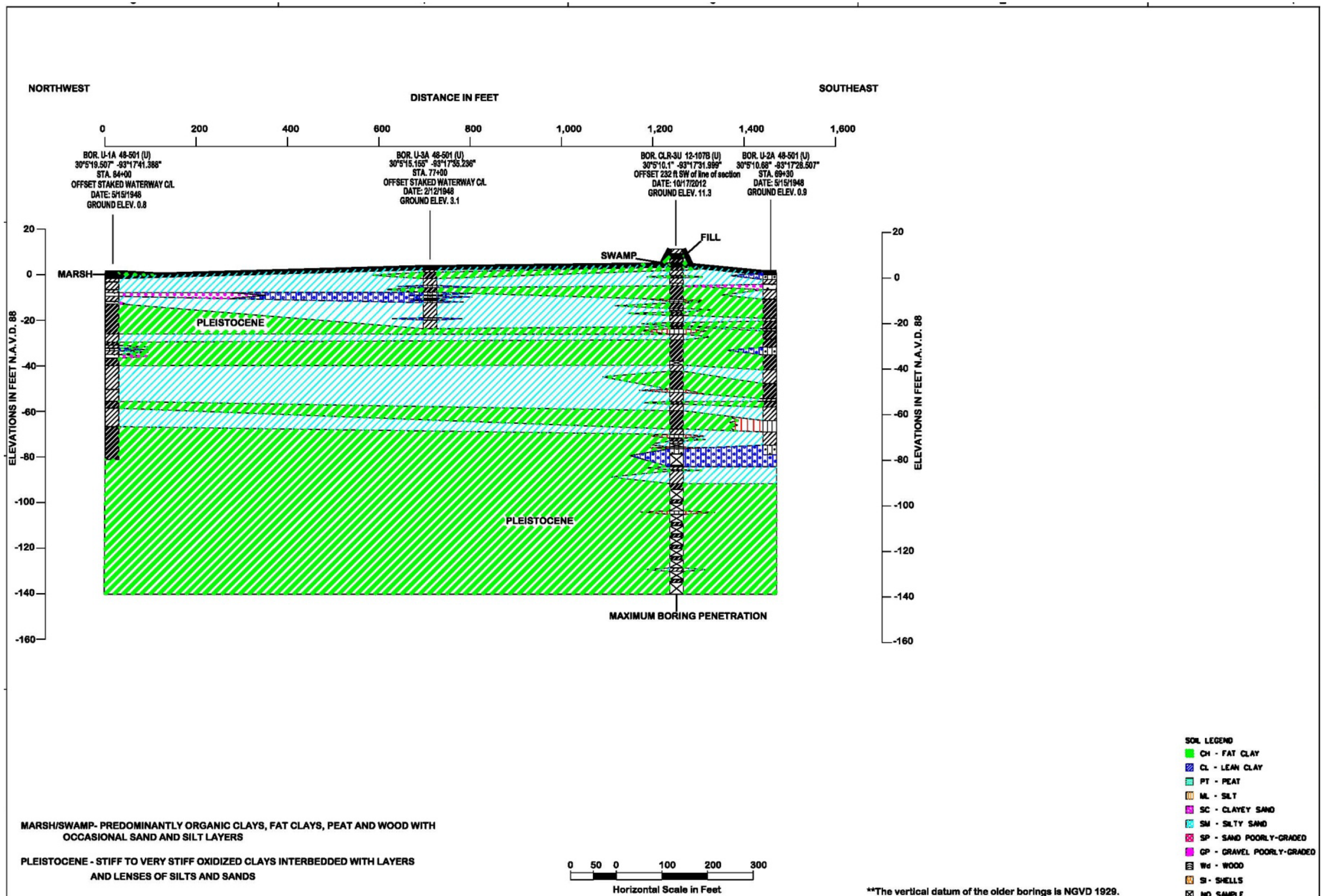

Figure L-19. Soil and Geologic Profile

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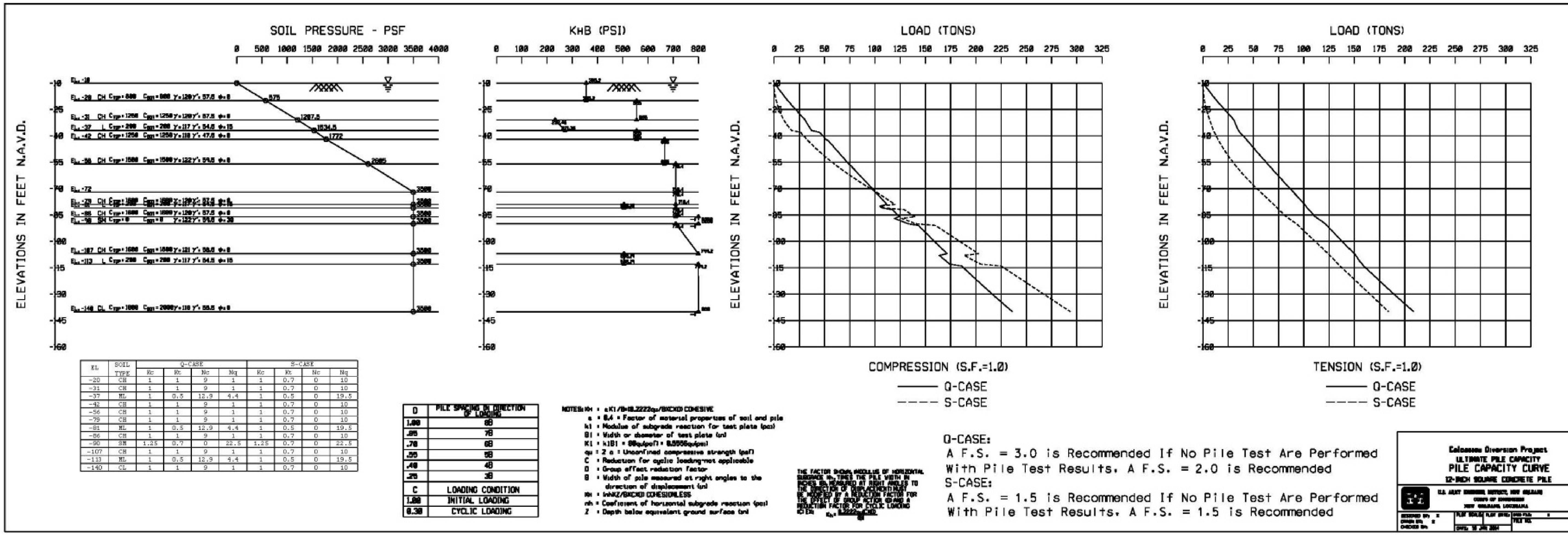

Figure L-20. Pile Capacity – 12-inch Concrete

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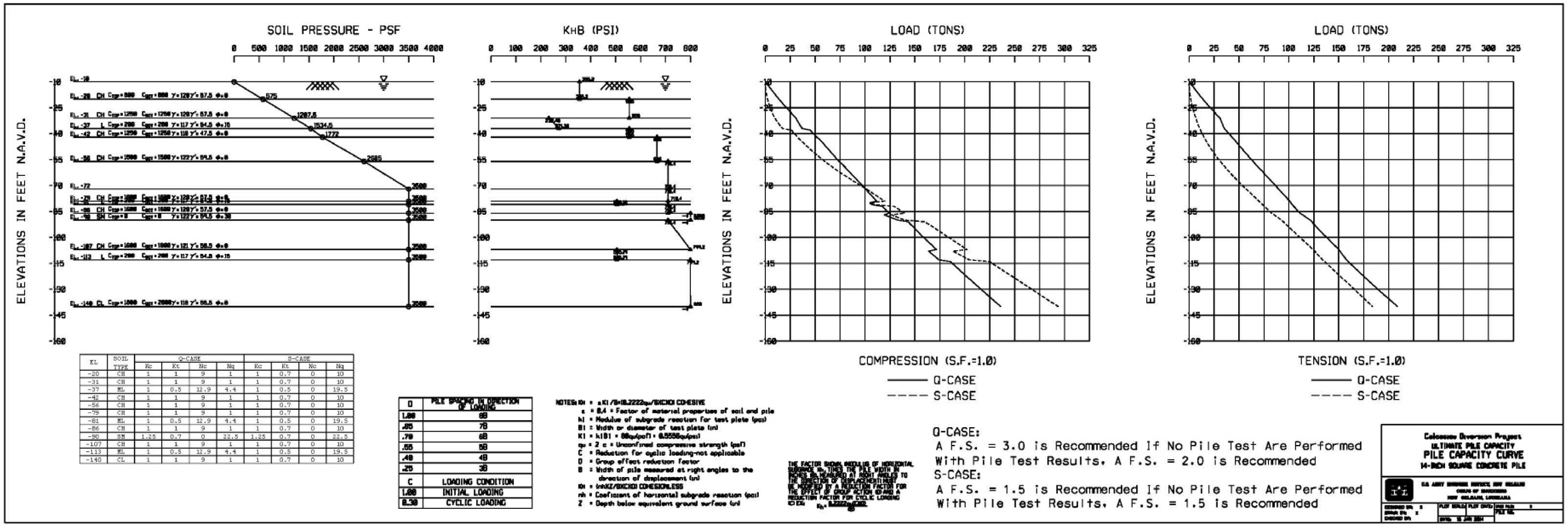

Figure L-21. Pile Capacity –14-inch Concrete

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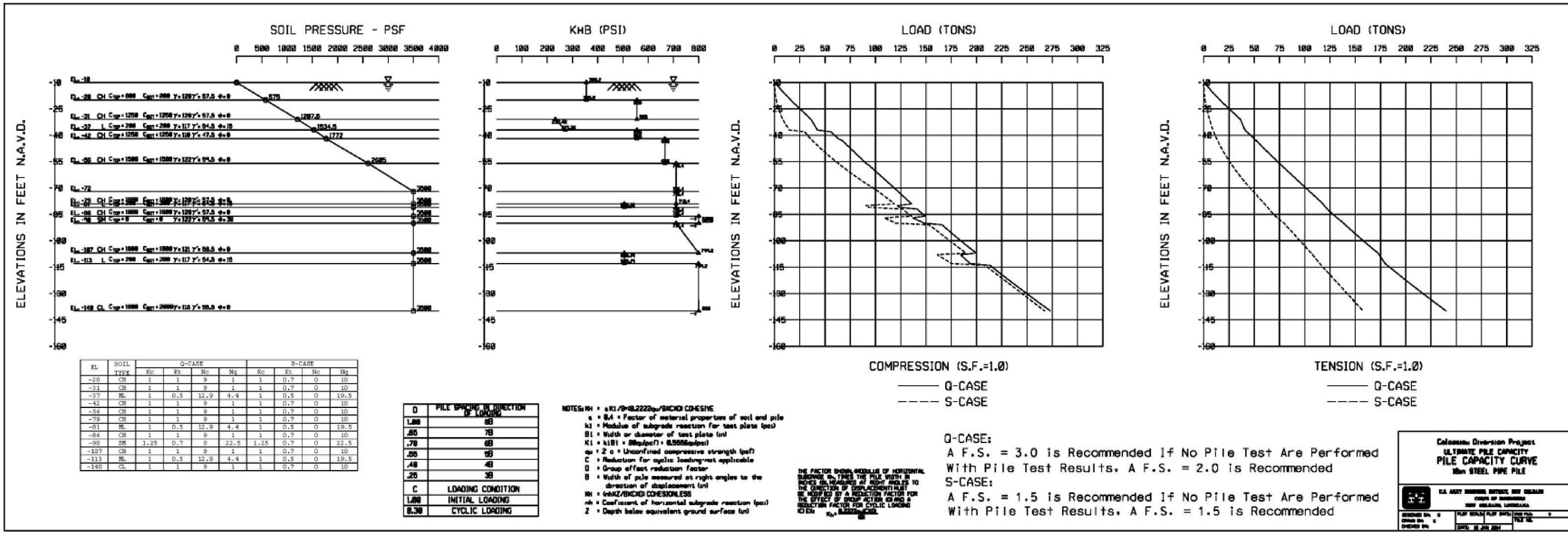

EL	SOIL TYPE	Q-CASE				S-CASE			
		Kc	Kt	Nc	Nq	Kc	Kt	Nc	Nq
-20	CH	1	1	9	1	1	0.7	0	10
-31	CH	1	1	9	1	1	0.7	0	10
-37	ML	1	0.5	12.9	4.4	1	0.5	0	19.5
-42	CH	1	1	9	1	1	0.7	0	10
-56	CH	1	1	9	1	1	0.7	0	10
-79	CH	1	1	9	1	1	0.7	0	10
-81	ML	1	0.5	12.9	4.4	1	0.5	0	19.5
-86	CH	1	1	9	1	1	0.7	0	10
-90	SM	1.25	0.7	0	22.5	1.25	0.7	0	22.5
-107	CH	1	1	9	1	1	0.7	0	10
-113	ML	1	0.5	12.9	4.4	1	0.5	0	19.5
-140	CL	1	1	9	1	1	0.7	0	10

Figure L-22. Pile Capacity –18-inch Pipe

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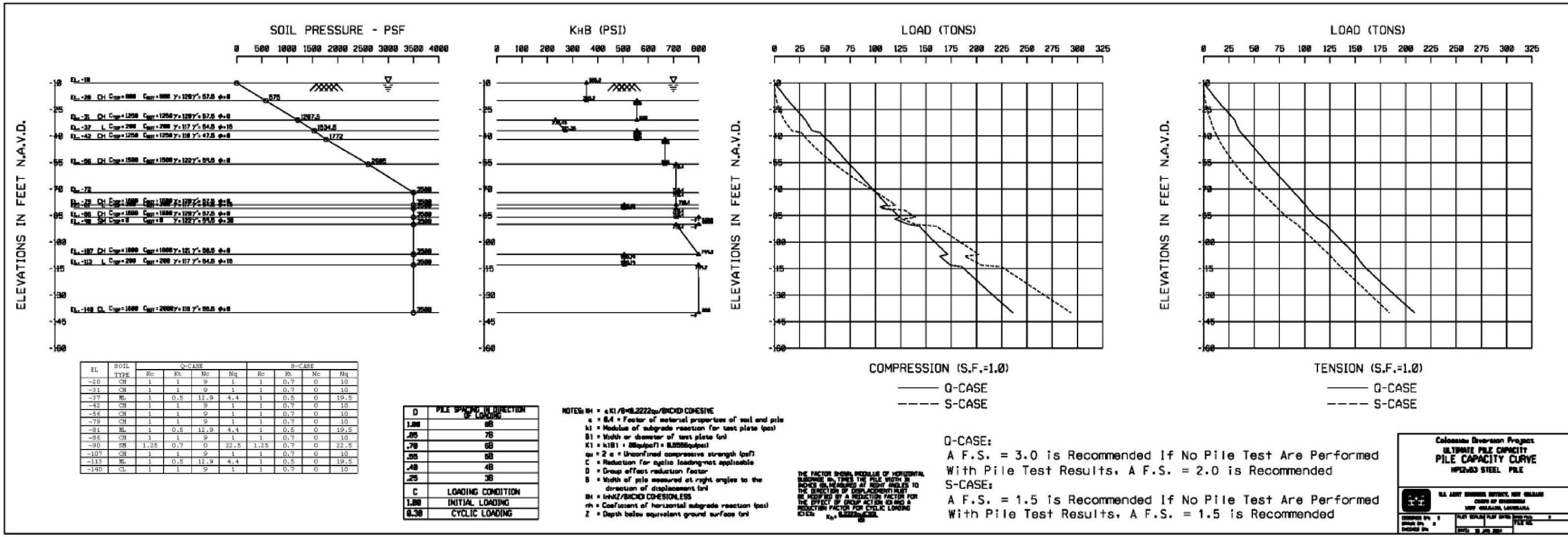

EL	SOIL TYPE	Q-CASE Kc	Kt	Nc	Nq	S-CASE Kc	Kt	Nc	Nq
-20	CH	1	1	9	1	1	0.7	0	10
-31	CH	1	1	9	1	1	0.7	0	10
-37	ML	1	0.5	12.9	4.4	1	0.5	0	19.5
-42	CH	1	1	9	1	1	0.7	0	10
-56	CH	1	1	9	1	1	0.7	0	10
-79	CH	1	1	9	1	1	0.7	0	10
-81	ML	1	0.5	12.9	4.4	1	0.5	0	19.5
-86	CH	1	1	9	1	1	0.7	0	10
-90	SM	1.25	0.7	0	22.5	1.25	0.7	0	22.5
-107	CH	1	1	9	1	1	0.7	0	10
-113	ML	1	0.5	12.9	4.4	1	0.5	0	19.5
-140	CL	1	1	9	1	1	0.7	0	10

Figure L-23. Pile Capacity –HP 12x53 Steel

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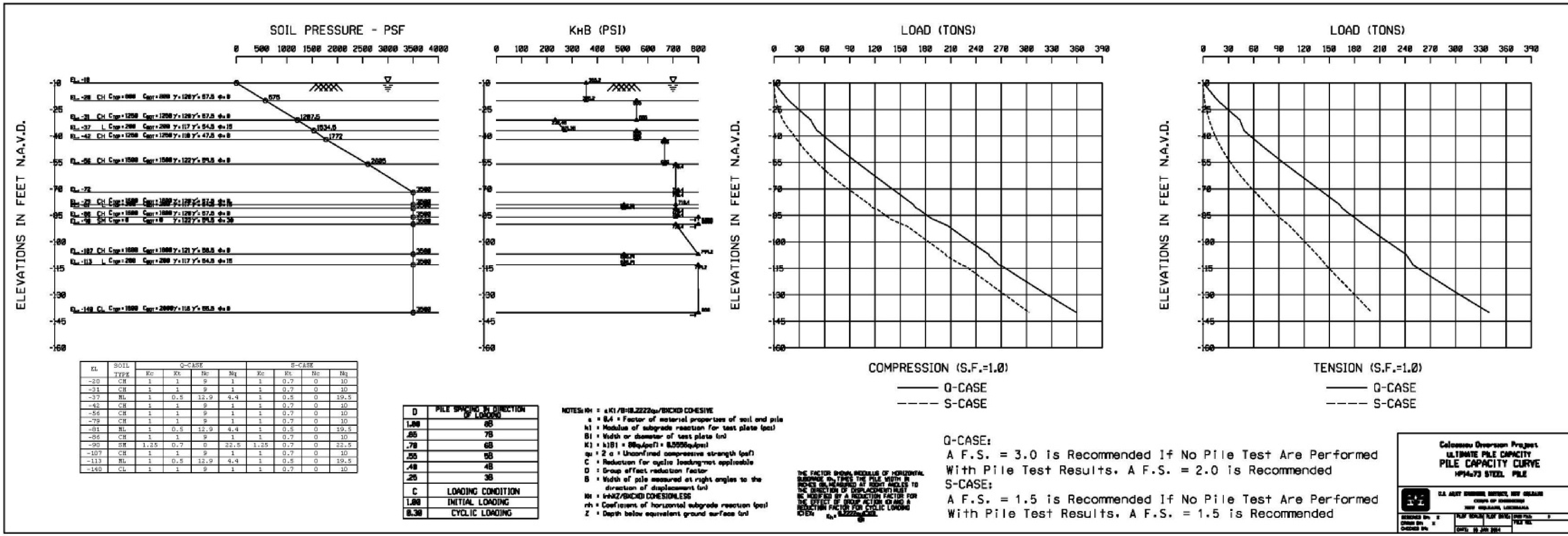

Figure L-24. Pile Capacity –HP 14x73 Steel

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CIVIL DESIGN

I. ALTERNATIVE 1 – CULVERT STRUCTURE AND ALTERNATIVE 2 – 3,700 CFS PUMP STATION

Approximately 3,650 linear feet of dredging for the inflow and outflow channels will be required to tie the GIWW to Bayou Choupique. The channel will be dredged to elevation (-) 12.0 NAVD88 and have an 80-foot bottom width (approximately 170,000 cubic yards) with 1:3 side slopes. Approximately 300 feet of riprap with a 3-foot thickness will placed on geotextile fabric, on either side of the structure. All material from the channel dredging will be hydraulically placed in the open water areas between Black Bayou and the GIWW. The material will be contained by earthen weirs and closures adjacent to the Bayou.

Figure L-25 shows the location of the features for Alternatives 1 and 2.

II. ALTERNATIVE 3 – BLACK BAYOU CULVERTS

The channel will be dredged to elevation (-) 9.0 NAVD88 and have a 120-foot bottom width for 200 feet adjacent to the structure and transition to (-) 6.0 NAVD88 and an 80-foot bottom width on the inflow channel (approximately 64,000 cubic yards) with 1:3 side slopes. Approximately 200 feet of riprap with a 3-foot thickness will be placed on geotextile fabric, on either side of the structure. The dredge material from the channel will be hydraulically placed in the open water area adjacent to Hwy 384 and between Black Bayou and the GIWW. The material will be contained by earthen weirs and closures adjacent to the Bayou and Hwy 384.

Figure L-26 shows the location of the features of Alternative 3.

III. ALTERNATIVE 4- 2,000 CFS PUMP STATION AND ALTERNATIVE 5 – 3,700 CFS PUMP STATION

The channel will be dredged to elevation (-) 12.0 NAVD88 and have an 80-foot bottom width (approximately 67,000 cubic yards). Approximately 300 feet of riprap with a 3-foot thickness will be placed on either side of the structure. The dredge material from the channel will be hydraulically placed in the open water areas adjacent to Hwy 384 and between Black Bayou and the GIWW. The material will be contained by earthen weirs and closures adjacent to the Bayou and Hwy 384.

Figure L-27 shows the location of the features for Alternatives 4 and 5.

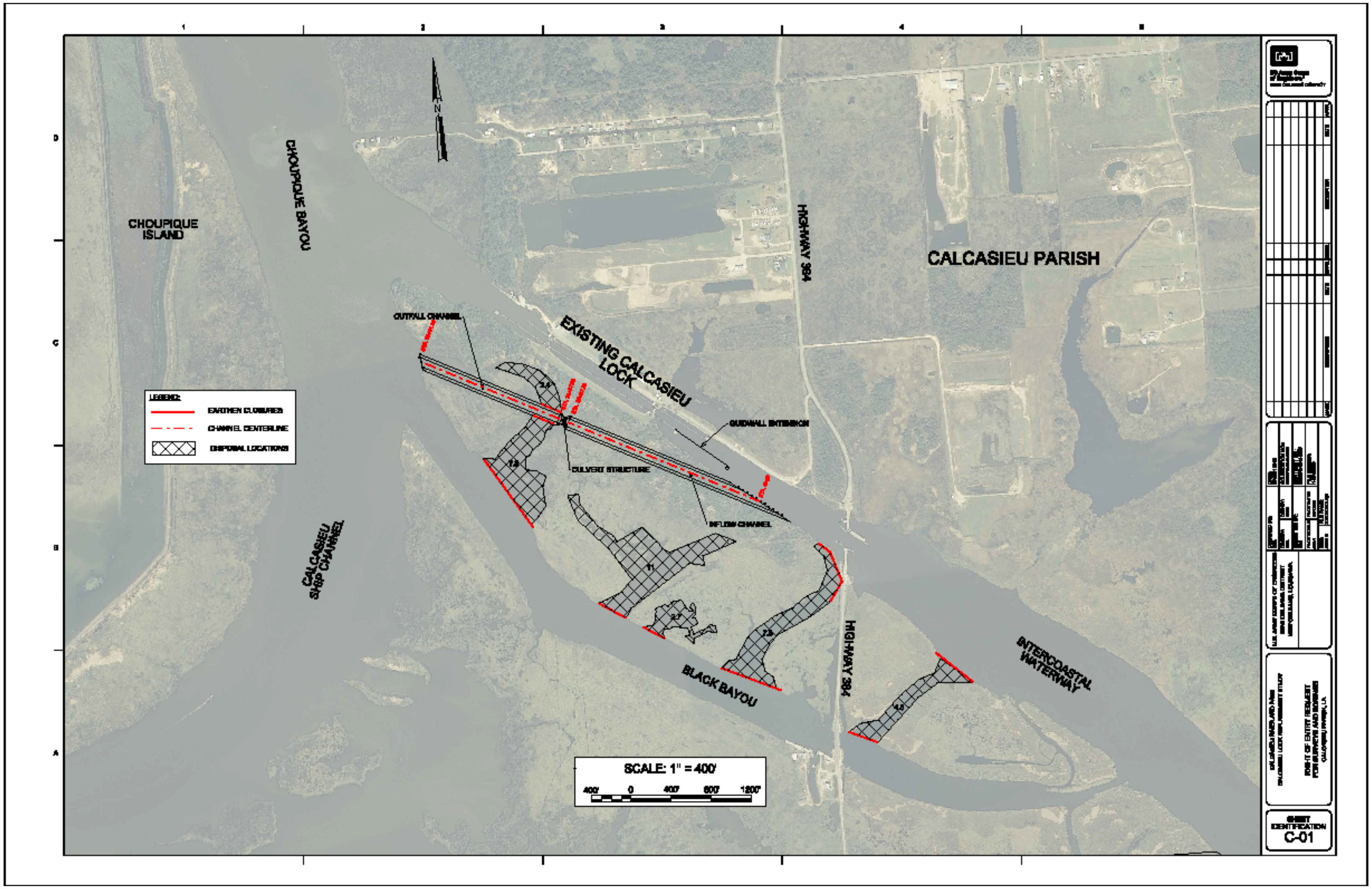

Figure L-25. Alternative 1 – Culvert Structure Dredging; Alternative 2 – 3,700 cfs Pump Station

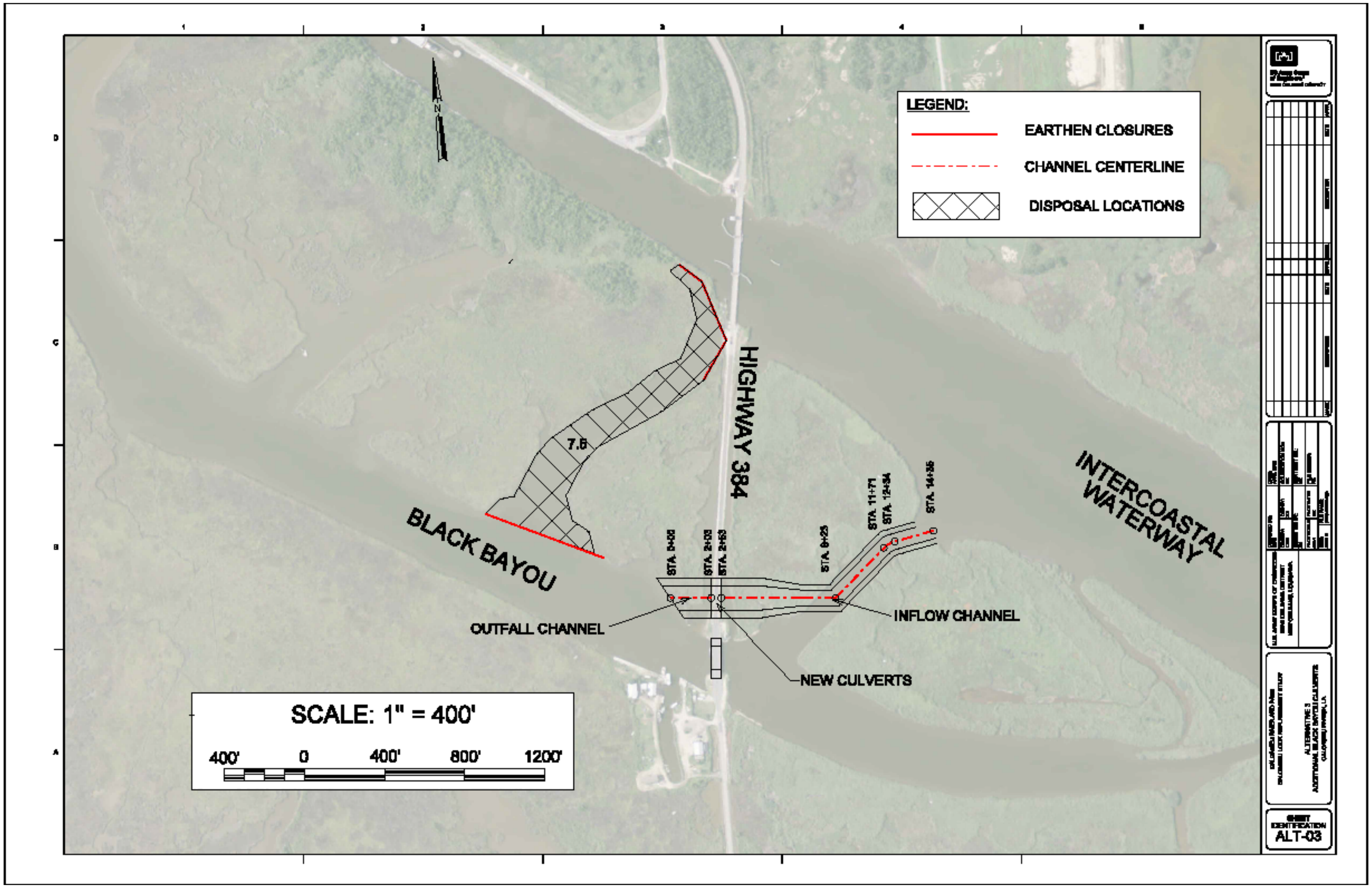

Figure L-26. Alternative 3 – Black Bayou Culverts

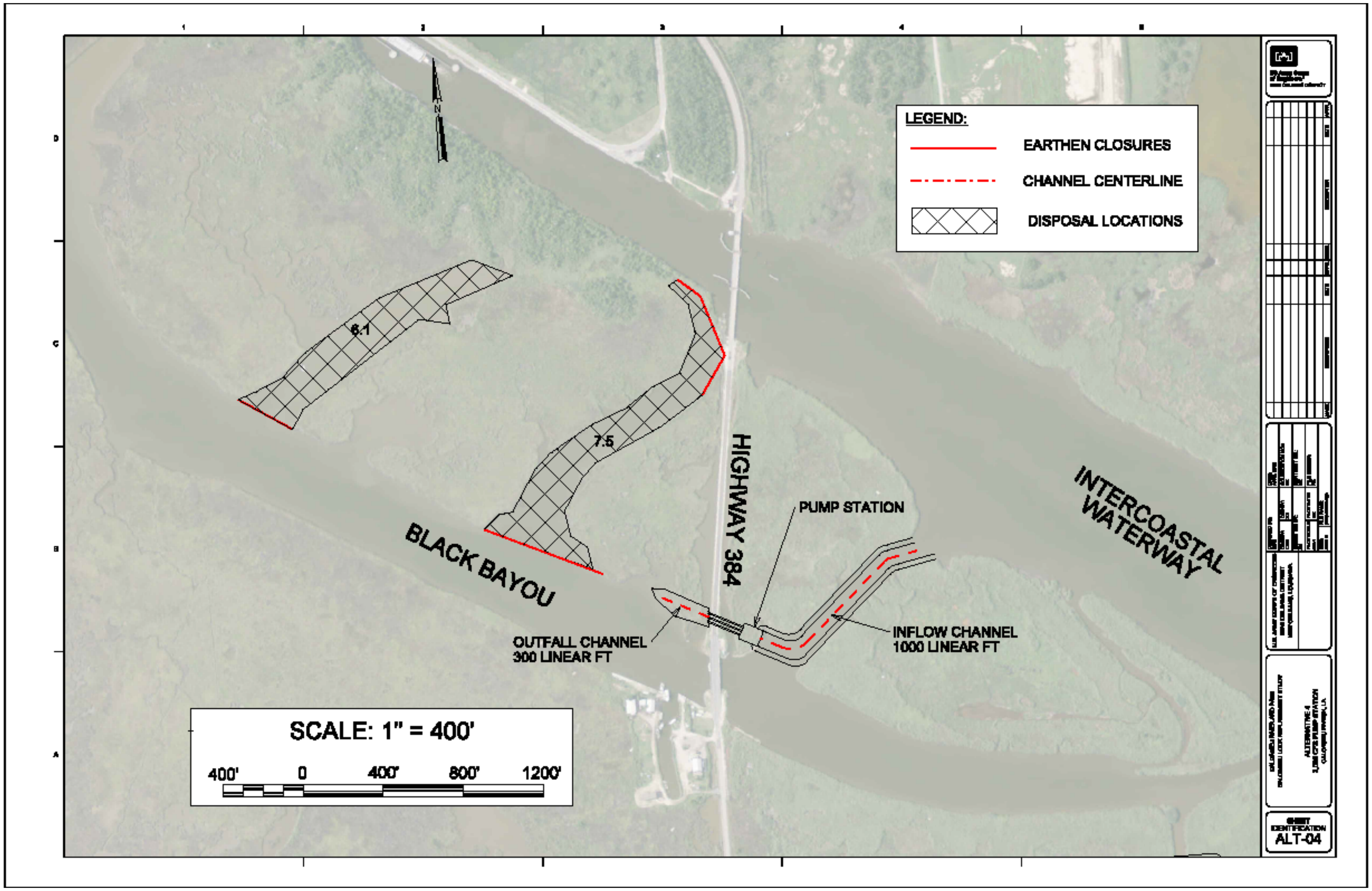

Figure L-27. Alternative 4- 2,000 cfs Pump Station; Alternative 5 – 3,700 cfs Pump Station

STRUCTURAL

GENERAL

The general configuration of the alternatives for this project were based on a variety of considerations, among them hydraulic requirements, similar structures performing the same function, and utilizing existing designs from other projects. All structures will be reinforced concrete and cast-in-place.

All designs were performed in accordance with applicable Corps of Engineers and technical publications, and industry codes. All structures will be constructed using conventional construction equipment and techniques. The contractor will be required to provide dewatering systems (where necessary) in order to construct foundations in a near dry atmosphere. The contractor will also be required to provide a system of shoring or open excavation to safely facilitate construction procedures.

The size and type of mechanical and electrical components for the project features were selected based on a variety of considerations, among them, similar features performing the same function, and utilizing existing designs from other projects.

I. ALTERNATIVE 1 – CULVERT STRUCTURE

The culvert structure consists of five 9-foot x 14-foot openings that will allow for the passage of the additional flow. The structure is pile-founded, reinforced concrete with cast iron sluice gates that can be closed when salinity levels in the ship channel are too high. The structure is 82-feet wide and 100-feet long. The invert of the structure is elevation (-) 6.0 NAVD88, with the top of the structure at (+) 14.0 NAVD88. The top of the culvert is at (+) 5.0 NAVD88, which is higher than the anticipated flow line thru the area, so water cannot overtop the structure. Concrete and structural steel member sizes were assumed based on similar structures of equivalent size with similar loadings, therefore, no stress analyses were performed in this phase.

Preliminary assumptions of pile sizes, spacing, and pile tip elevations were based on the design of similar structures found in the vicinity. Verification of the pile assumptions, along with any adjustments, was accomplished with the use of pile capacity curves that were developed for similar soils. A more accurate determination of soil properties was not possible due to the absence of reliable borings; therefore pile tip elevations may be adjusted in the next stage of design.

The structure can be dewatered for maintenance purposes with the use of steel bulkheads on either side of the sluice gates. The operation of the gates can be done remotely with hydraulic motors; therefore, there is no requirement to man the structure during events in which the structure is opened. Power was assumed to be provided from the Calcasieu Lock area.

Refer to figures L-28, L-29 and L-30 for the location and layout of the culvert structure.

Figure L-28. Alternative 1 - Plan Location

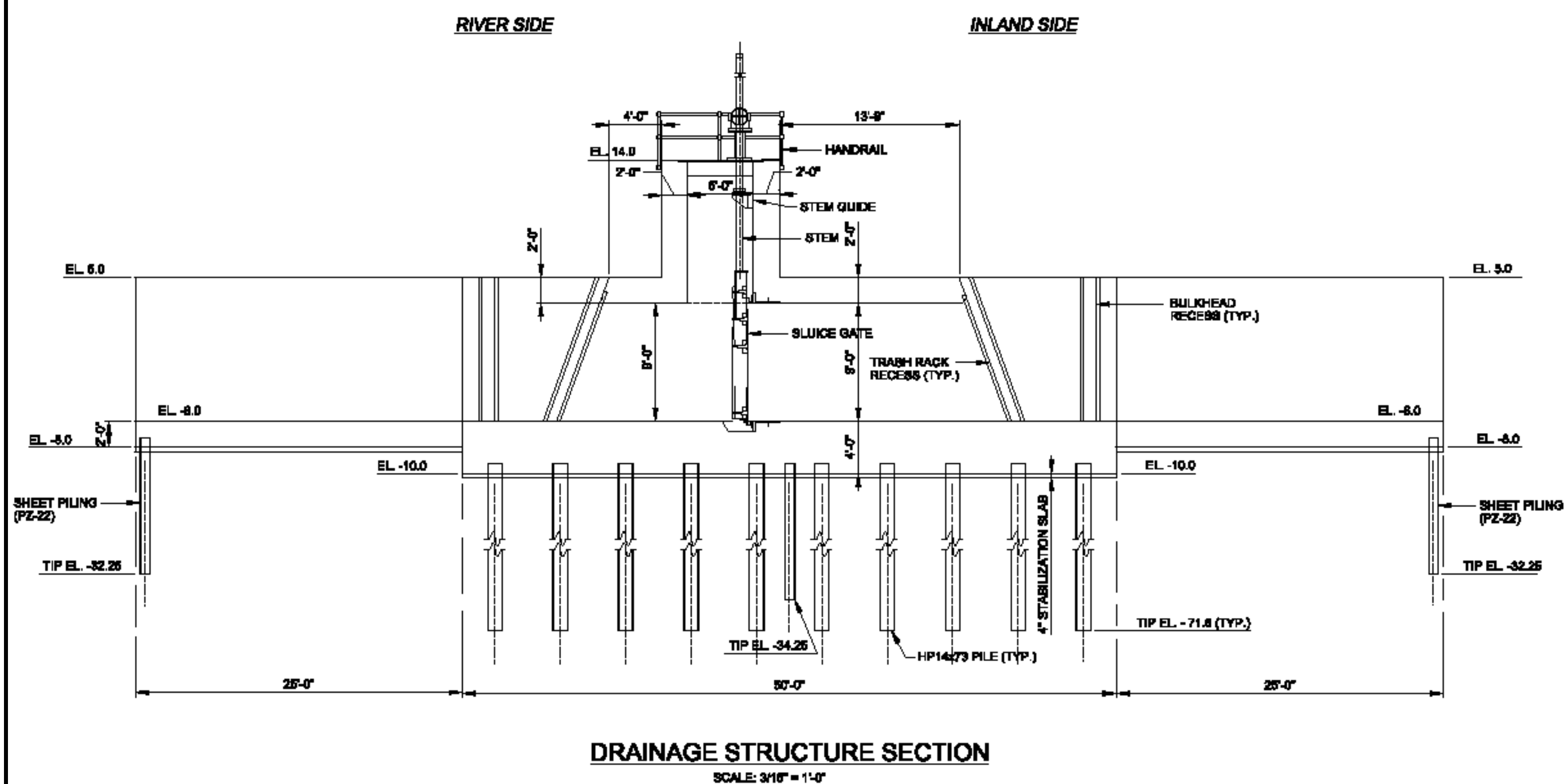

Figure L-29. Alternative 1 - Structure – Section View

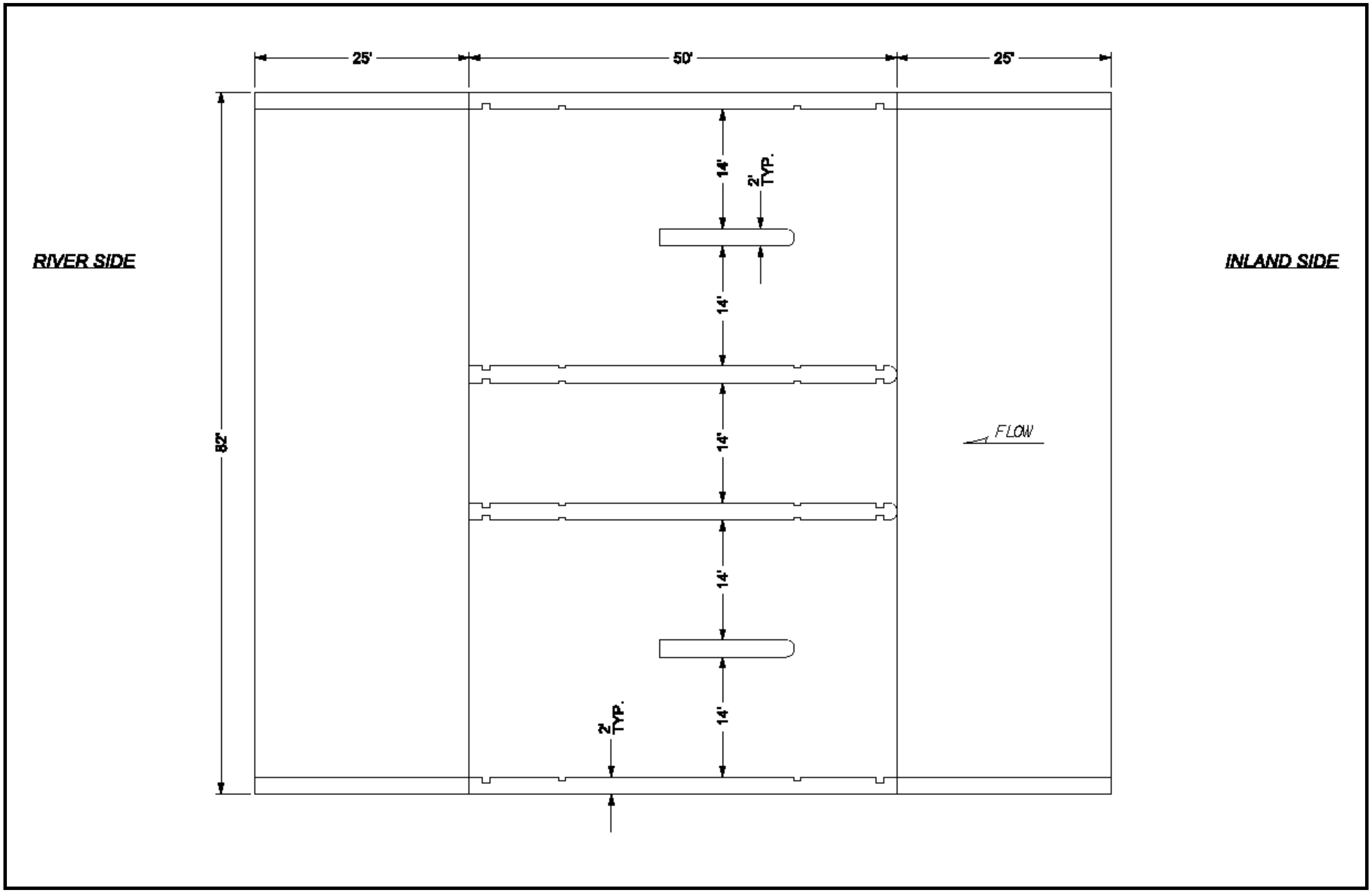

Figure L-30. Alternative 1 - Structure – Plan View

II. ALTERNATIVE 2 – 3,700 CFS PUMP STATION

The pump station for this alternative was cost indexed from a 1,000 cfs, pump station used in the New Orleans to Venice project. The pump station consists of four 900 cfs vertical pumps built on a pile foundation, enclosed by a prefabricated building.

Figures L-31 and L-32 show the location and layout of the pump station.

Since this alternative is adjacent to the existing lock, the following factors were not taken into consideration in the cost, but would be added after further investigation:

- Access to the proposed station. An access road would need to be constructed from Hwy 384 to the pump station, approximately 2 miles.

- Utilities needed for the station. Since this station would be manned during operation, a full service of utilities is required.

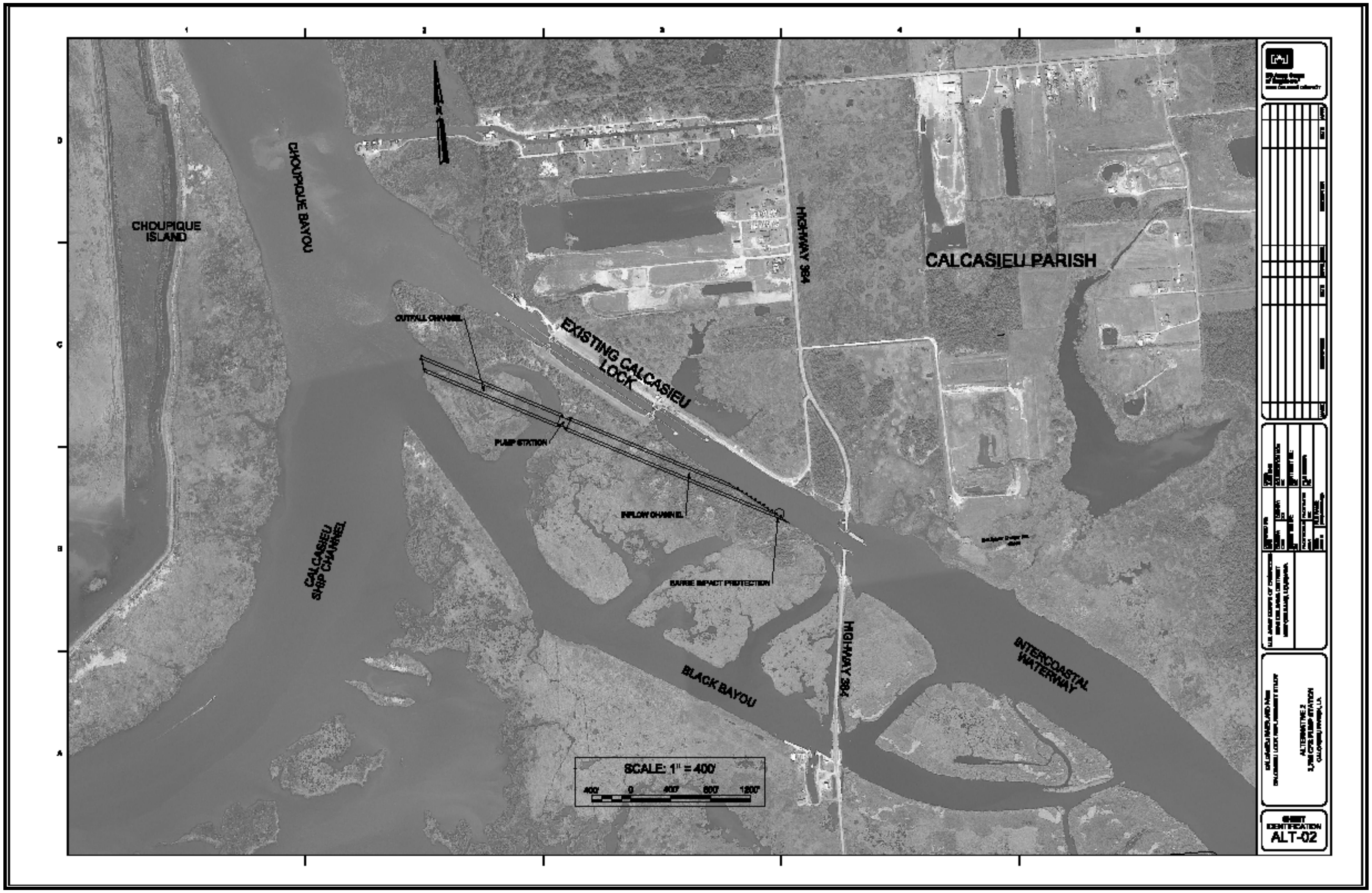

Figure L-31. Alternative 2 - Plan Location

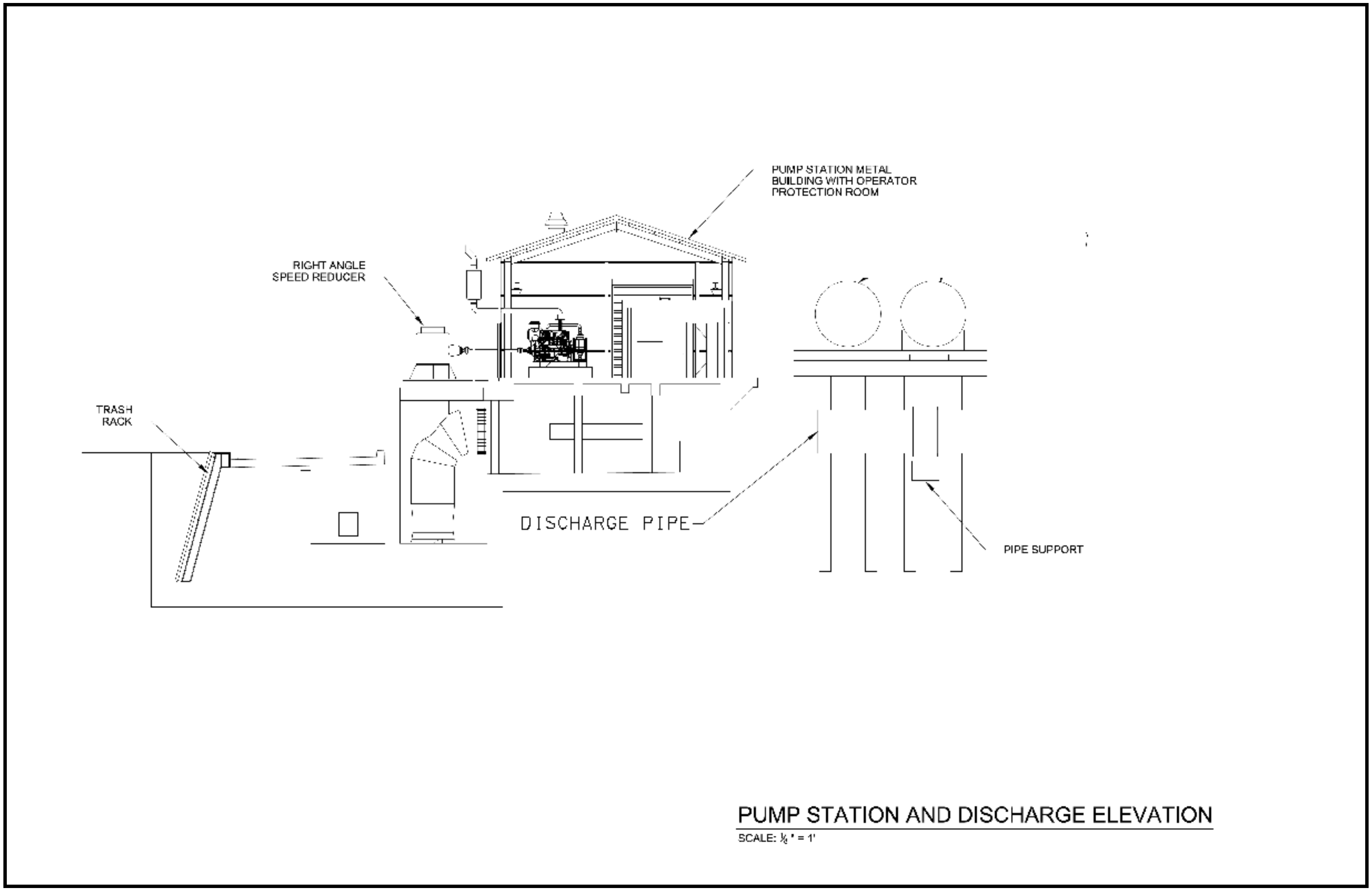

Figure L-32. Alternative 2 - Typical Pump Station

III. ALTERNATIVE 3 – BLACK BAYOU STRUCTURE

The structure for this alternative is similar to the existing Black Bayou structure already in place. The structure is ten 10-foot x 10-foot concrete box culverts, at invert elevation (-) 9.0 NAVD88. The structure is directly beneath Hwy 384. The culverts include flap gates which close when water from the Calcasieu Lake Basin is higher than the inland water elevation.

According to local and State officials, the existing structure is not able to operate as intended and has been closed for a few years. A team of engineers is currently evaluating the structure and will make a recommendation on repairs. The cost of these repairs is not included in the Engineering cost of this alternative. If the state's engineering team determines major changes are needed to the structure, then the same changes should be made to the structure used in this alternative.

Also part of this alternative is a structural weir on the inland side of the existing black bayou culverts. The weir consists of 40-ft long vinyl sheet pile and 650-lb riprap, placed from elevation (-) 3.0 sloping down on a 1:2 to elevation (-) 9.0.The top of the sheet pile is at elevation (+) 3.0 NAVD88.

Figure L-33 shows the location and layout of the culvert structure and structural weir.

Figure L-33. Alternative 3 - Plan View

IV. ALTERNATIVE 4 – 2,000 CFS PUMP STATION AT BLACK BAYOU

The pump station for this alternative was cost indexed from a 1,000 cfs pump station used in the New Orleans to Venice project. The pump station consists of four 500 cfs vertical pumps built on a pile foundation, enclosed by a prefabricated building.

Figures L-34 and L-35 show the location and layout of the pump station.

Since this alternative is adjacent to Hwy 384, the following factors were not taken into consideration in the cost, but would be added after further investigation:

- Discharge pipes will need to pass under Hwy 384; therefore the pipes will need to be jack and bored.
- Another option would include constructing a new Hwy 384 Bridge over the discharge channel.
- Also part of this alternative is a structural weir on the inland side of the existing black bayou culverts. The weir consists of 40-ft long vinyl sheet pile and 650-lb riprap, placed from elevation (-) 3.0 sloping down on a 1:2 to elevation (-) 9.0.The top of the sheet pile is at elevation (+) 3.0 NAVD88.

Figure L-34. Alternative 4 - Plan View

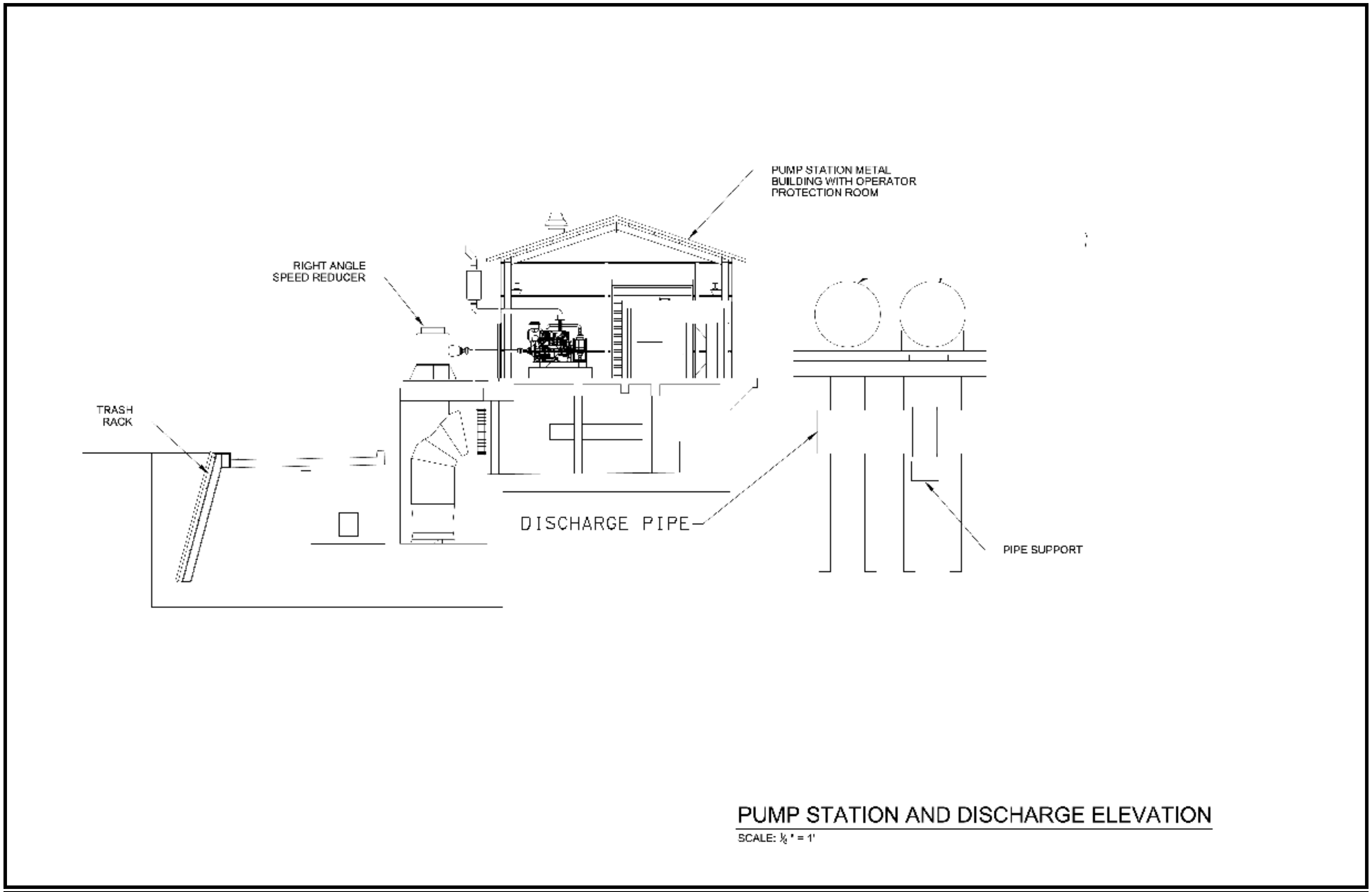

Figure L-35. Alternative 4 - Typical Pump Station

V. ALTERNATIVE 5 – 3,700 CFS PUMP STATION AT BLACK BAYOU

The pump station for this alternative was cost indexed from a 1,000 cfs pump station used in the New Orleans to Venice project. The pump station consists of four 900 cfs vertical pumps built on a pile foundation, enclosed by a prefabricated building.

Refer to figures L36-37 for location and layout of pump station.

Since this alternative is adjacent to Hwy 384, the following factors were not taken into consideration in the cost, but would be added after further investigation:

- Discharge pipes will need to pass under Hwy 384; therefore the pipes will need to be jack and bored.
- Another option would include constructing a new Hwy 384 bridge over the discharge channel.
- Also part of this alternative is a structural weir on the inland side of the existing black bayou culverts. The weir consists of 40-ft long vinyl sheet pile and 650-lb class riprap, placed from elevation (-) 3.0 sloping down on a 1:2 to elevation (-) 9.0.The top of the sheet pile is at elevation (+) 3.0 NAVD88.

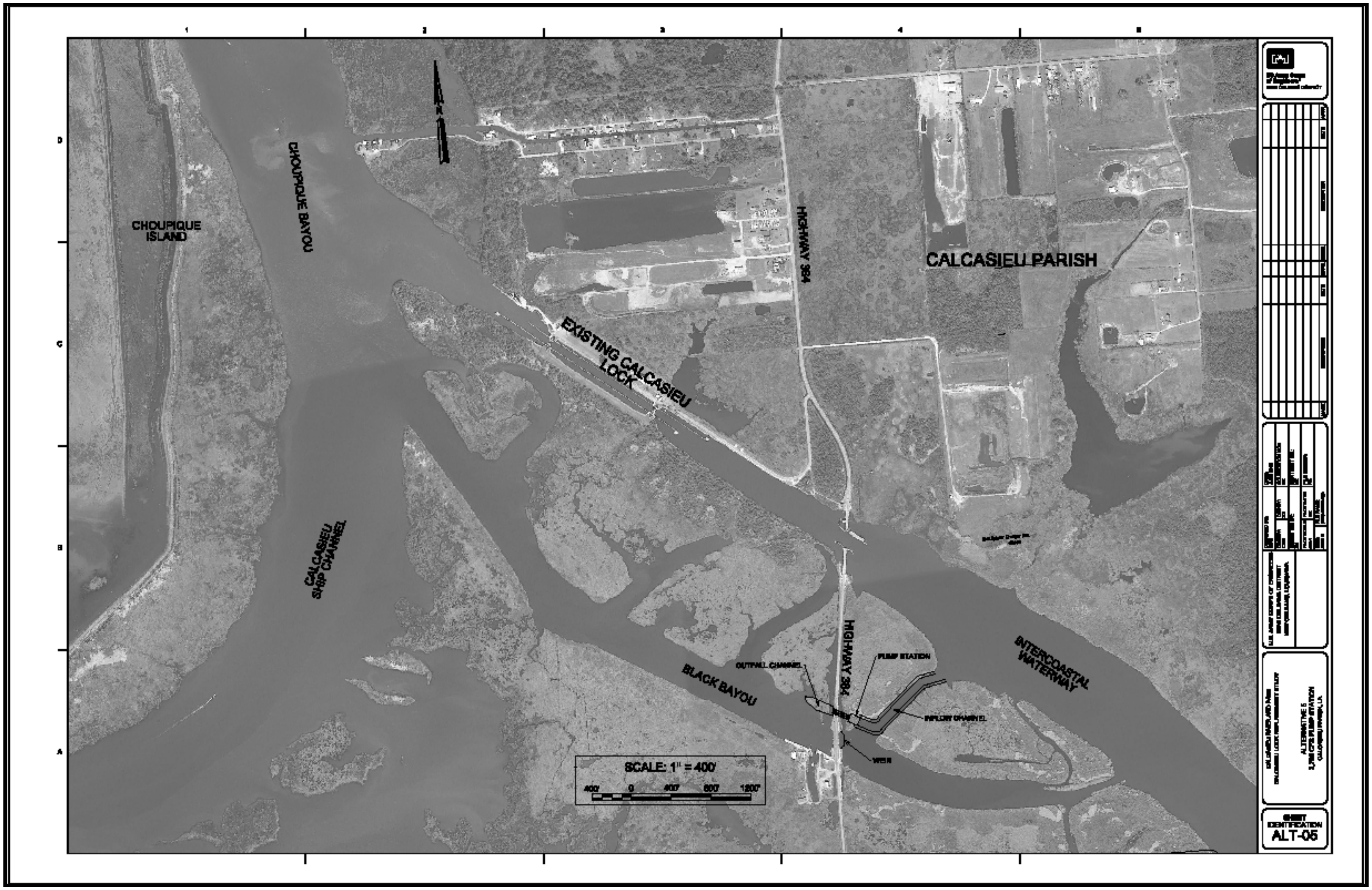

Figure L-36. Alternative 5 - Plan View

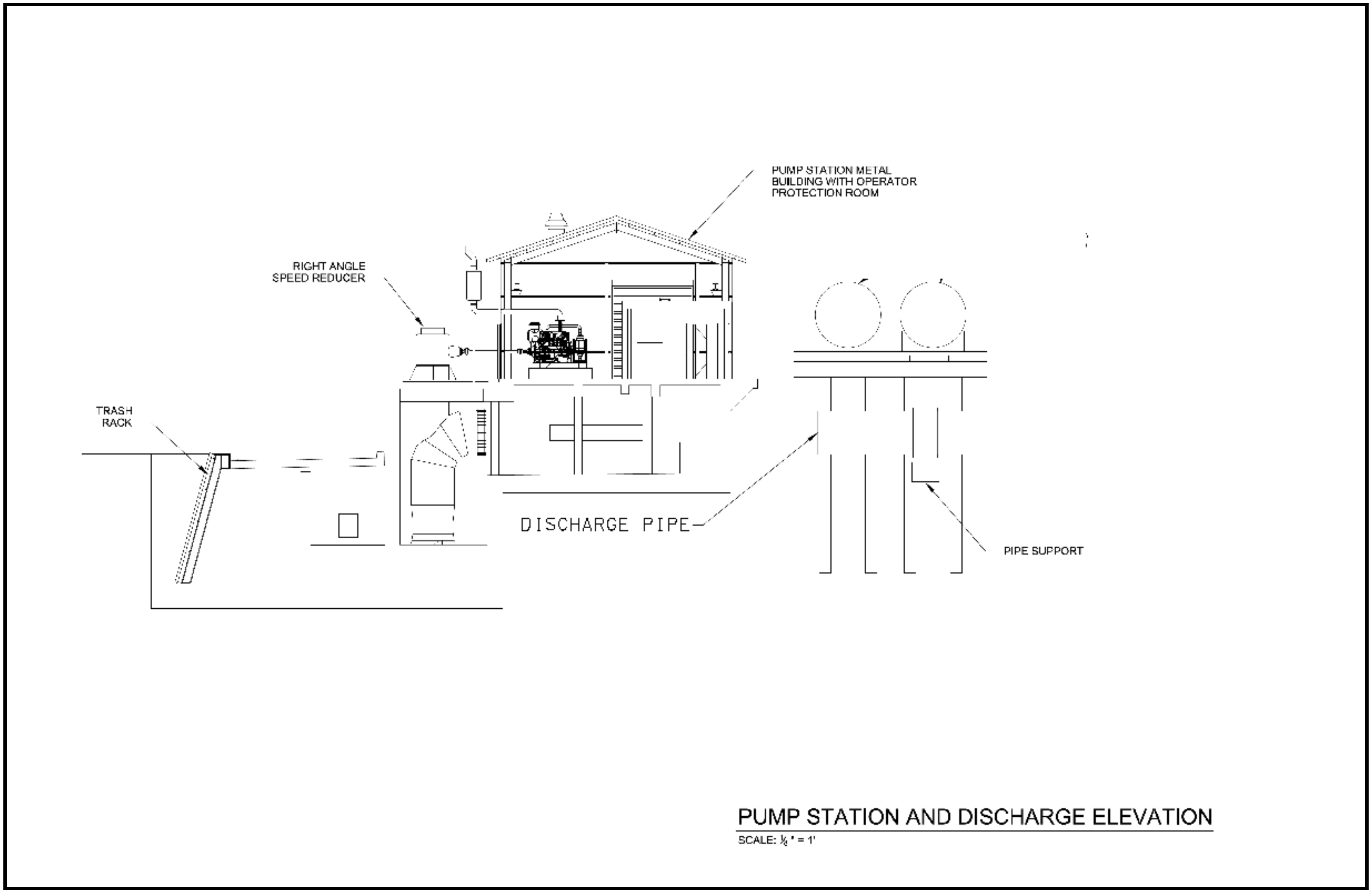

Figure L-37. Alternative 5 - Typical Pump Station

COST ENGINEERING

I. ROUGH ORDER OF MAGNITUDE ESTIMATES

A. Alternative 1 – Cost Estimate

Item	Quantity	Unit	Unit Price	Amount	Contingencies	Project Cost
Mobilization and Demobilization	1	EA	647,498.88	$647,498.88	$161,875	$809,374
Care & Diversion of Water						
Cofferdam - PZ-40	24,200	SF	46.35	$1,121,670.00	$280,418	$1,402,088
Dewatering System	LS	--------	170,460.36	$170,460.36	$42,615	$213,075
12” Bedding	900	CY	64.37	$57,933.00	$14,483	$72,416
Cofferdam Removal	24,200	SF	1.48	$35,816.00	$8,954	$44,770
Earthwork for Structure						
Clearing & Grubbing	0.25	AC	46,697.61	$11,674	$2,919	$14,593
Structural Excavation	7,900	CY	10.71	$84,609	$21,152	$105,761
Backfill - Semi-compacted	2,000	CY	87.62	$175,240	$43,810	$219,050
24” Riprap (dry)	1,800	TONS	44.39	$79,902	$19,976	$99,878
Geotextile	1,700	SY	4.55	$7,735	$1,934	$9,669
Access Road						
12” Stone	570	TONS	45.98	$26,209	$6,552	$32,761
Geotextile	1,100	SY	4.55	$5,005	$1,251	$6,256
Foundation						
25-ft long PZ-22 Steel Sheet Piling	6,200	SF	35.25	$218,550	$54,638	$273,188
OPTION 1: 62-ft long 14” x 14” PPC Piling	7,400	LF	50.92	$376,808	$94,202	$471,010
OPTION 2: 63-ft long HP 14”x73” Piling	6,100	LF	103.21	$629,581	$157,395	$786,976
Reinforced Concrete						
Base Slab	910	CY	339.12	$308,599	$77,150	$385,749
Walls	350	CY	582.17	$203,760	$50,940	$254,699
Roof	130	CY	741.20	$96,356	$24,089	$120,445
Unreinforced Concrete						
Stabilization Slab	100	CY	278.83	$27,883	$6,971	$34,854
Impact Protection						
5 Timber Pile Cluster (60 feet long)	14	EA	25,000	$350,000	$87,500	$437,500

A. Alternative 1 – Cost Estimate

Miscellaneous Metals						
Embedded Metals	34,100	LBS	7.18	$244,838	$61,210	$306,048
Hand Rail	180	LF	21.76	$3,917	$979	$4,896
Gates & Associated Items						
OPTION 1: 14'x9' Cast Iron Sluice Gates	5	EA	350,439.03	$1,752,195	$438,049	$2,190,244
OPTION 2: 14'x9' Stainless Slide Gates	5	EA	398,211.49	$1,991,057	$497,764	$2,488,822
Emergency Bulkheads	22,500	LBS	7.18	$161,550	$40,388	$201,938
Gate Hoist Support Beam	15,100	LBS	7.18	$108,418	$27,105	$135,523
Electrical						
Power & Lighting	LS	--------	481,363.48	$481,363	$120,341	$601,704
Emergency Generator	LS	--------	1,607.27	$1,607	$402	$2,009
Mechanical						
Remote Operating Machinery	LS	--------	673,398.84	$673,399	$168,350	$841,749
Dredging						
Mobilization and Demobilization	1	L.S.	$959,215.68	$959,215.68	$239,803.92	$1,199,019
Dredging - Inflow Channel (No overdepth included)	105,000	CYS	$7.17	$752,850.00	$188,212.50	$941,062.50
Dredging -Outflow Channel (No overdepth included)	65,000	CYS	$7.40	$481,000.00	$120,250.00	$601,250.00
Rip Rap	17,200	TONS	$42.17	$725,324.00	$181,331.00	$906,655.00
Earthen Closure	4,000	LF	$67.02	$268,080.00	$67,020.00	$335,100.00
Earthen Weir (2.5 cy/lf)	16,500	LF	$19.48	$321,420.00	$80,355.00	$401,775.00
			TOTAL	**$10,940,884**	**$2,735,220**	**$13,676,106**

B. Alternatives 2, 3, 4, and 5

		First Cost of Construction	Real Estate	First Cost of Mitigation	Total First Cost
Alternative 1	Culvert Structure	$13,676,106	$86,380	$550,000	$14,312,486
Alternative 2	South 3,700 Pump	$91,397,877	$86,380	$550,000	$92,034,257
Alternative 3	Black Bayou Culverts	$10,610,115	$89,380	$0	$10,699,495
Alternative 4	Black Bayou 2,000 Pump	$51,258,107	$89,380	$0	$51,347,487
Alternative 5	Black Bayou 3,700 Pump	$86,294,621	$89,380	$0	$86,384,001

II. OPERATIONS AND MAINTENANCE COSTS

A. Maintenance Cost Estimate - Culvert Structure

Work Item	Frequency	Cost	Total
Routine Maintenance	Annually	$50,000	$2,500,000
Rewiring and Machinery Replacement	Every 20 Years	$100,000	$250,000
Maintenance by Hired Labor Units	Every 5 Years	$250,000	$2,500,000
Dewatering & Monitoring/Major Repairs	Every 10 Years	$1,000,000	$4,500,000
Periodic Inspection Program	Every 5 Years	$60,000	$600,000
Sluice Gate Replacement	Every 25 Years	$3,000,000	$6,000,000
		TOTAL	**$16,350,000**

B. Maintenance Cost Estimate - Pump Station Alternatives

Work Item	Frequency	Cost	Total
Routine Maintenance	Annually	$250,000	$12,500,000
Rewiring and Machinery Replacement	Every 30 Years	$750,000	$1,250,250
Maintenance by Hired Labor Units	Every 3 Years	$675,000	$10,800,000
Pump Replacement	Every 30 Years	$5,000,000	$8,335,000
Periodic Inspection Program	Every 5 Years	$60,000	$600,000
		TOTAL	**$33,485,250**

C. Maintenance Cost Estimate - Black Bayou Culverts

Work Item	Frequency	Cost	Total
Routine Maintenance	Annually	$20,000	$1,000,000
Maintenance by Hired Labor Units	Every 5 Years	$250,000	$2,500,000
Dewatering & Monitoring/Major Repairs	Every 10 Years	$1,000,000	$4,500,000
Periodic Inspection (PI) Program	Every 5 Years	$60,000	$600,000
Existing CWPPRA Structure Rehab	Every 20 Years	$1,500,000	$5,250,000
Flap Gate Replacement	Every 20 Years	$1,000,000	$2,500,000
		TOTAL	**$16,350,000**

RELOCATIONS

The installation of a gated structure, borrowing of material, and the disposal of dredged or excavated material can be conducted with minimal to zero impact regarding utilities. No utilities within the project area were shown in the pipeline atlas.

RECOMMENDED PLAN DESIGN

I. GENERAL

This section describes the additional design and cost analysis done for the recommended plan. The recommended plan is a culvert structure located south of the existing lock as shown in Figure L-38. Details of the plan are described in the paragraphs below.

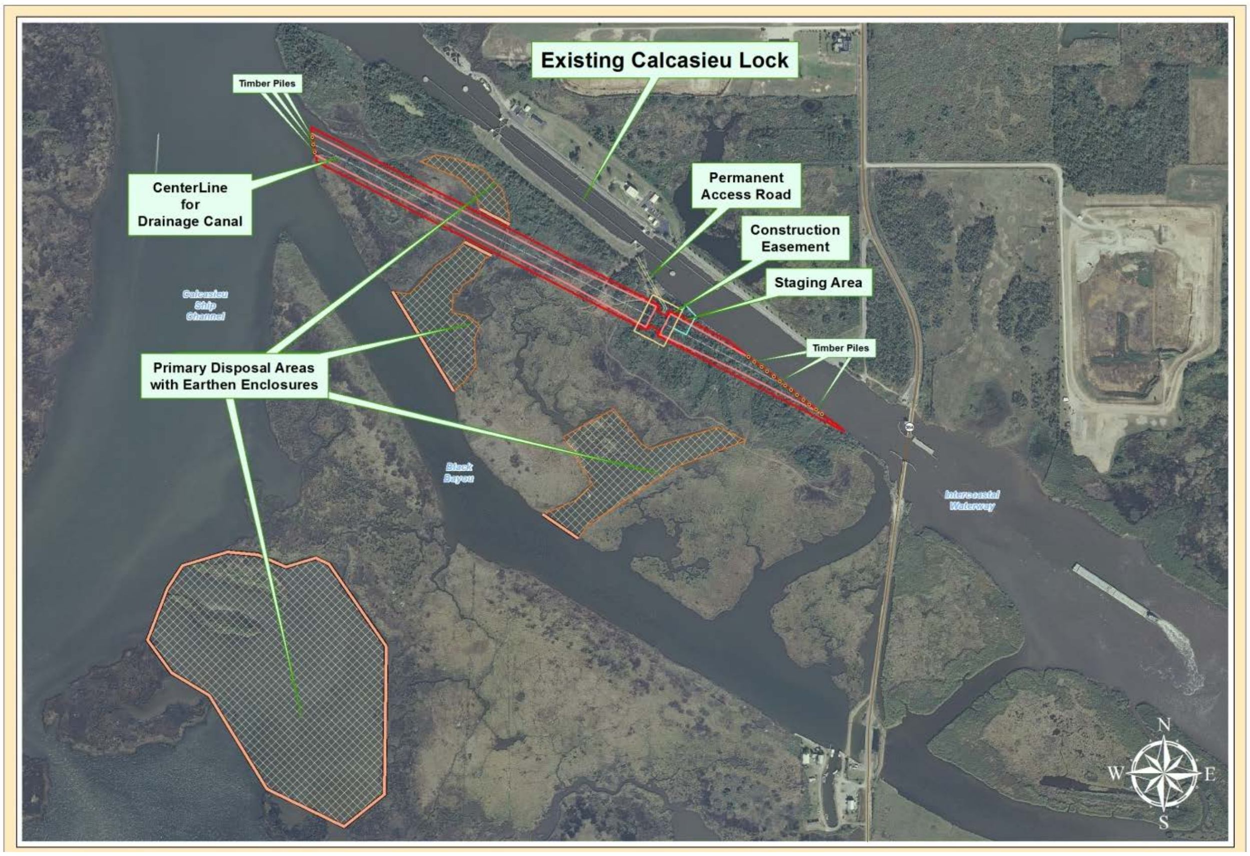

Figure L-38. Recommended Plan

II. HYDROLOGY AND HYDRAULICS

A. Summary. Drainage of rainfall runoff is now causing high head differentials at the existing Calcasieu Lock which results in excessive velocities for GIWW traffic and corresponding delays to navigation. The project delivery team (PDT) has determined that the best way to remedy this issue is by removing the drainage function of the existing Calcasieu Lock. The most cost effective way is to excavate another channel on the south side of the lock and add seven manually controlled gated culverts on this channel. This proposed new channel and culverts are estimated to reduce the existing positive head differential at the existing lock by an average of 65% and a minimum of 39%. This will translate to substantial savings to the navigation industry by relieving some of the flow which will allow the lock to be more frequently passable.

B. Background. The GIWW was first designed for navigation, but also introduced salinity problems. A series of locks were built to allow for navigation and to control salinity. The Calcasieu Lock is one of these structures. Issues with rainfall runoff also caused the unintended addition of a drainage function, which can cause navigation delays. The proposed adjacent channel with seven culverts will shift the purpose of drainage away from the navigation lock. Since salinity control will also be needed at this new structure, the gates are required. The original drainage culvert alternative was a bypass channel located adjacent to and parallel to the existing lock. This has now changed to a new channel located further away that was the original alignment of the south lock alternative. The final five alternatives are shown below in figure L-39. Notice that the three alternatives with pumps were ruled out due to the high cost of the pumps. The Black Bayou Culverts alternative was ruled out because it is too far away from the existing lock to be of any benefit and a new channel would not be excavated. Part of the solution involved excavating a new channel, which would displace that amount of water away from the east side of the east lock gate.

Economic Analysis

	Alt 1 – South 75' Gate	Alt 2 - South 3,700 CFS Pump	Alt 3 - Black Bayou Culverts	Alt 4 - Black Bayou 2,000 CFS Pump	Alt 5 - Black Bayou 3,700 CFS Pump
Construction	0.625	4.244	0.393	2.286	4.013
Engineering & Design (E&D)	0.050	0.340	0.031	0.183	0.321
Supervisory/Administration (S&A)	0.050	0.340	0.031	0.183	0.321
Mitigation	0.025	0.026	0.000	0.000	0.000
Real Estate	0.004	0.004	0.004	0.004	0.004
O&MRRR	0.232	0.548	0.228	0.597	0.552
Rehab Existing Black Bayou Structure	NA	NA	0.376	0.382	NA
Total Cost	0.986	5.500	1.063	3.636	5.211
Total Benefits	1.171	1.171	1.171	1.171	1.171
Net Benefits	0.185	(4.329)	0.108	(2.465)	(4.040)
Benefit-Cost Ratio (BCR)	1.19	0.21	1.10	0.32	0.22

Average Annual Benefit - Cost Summary
MOST LIKELY SCENARIO - Mid Traffic Forecast and Mid Sea-Level Rise
(Millions of FY2013 dollars, 3.75% discount/amortization rate, 2018 base year)

Figure L-39. Economic Analysis of Final Alternatives

C. Analysis. Fourteen original alternatives were compared based upon calculated emptying and filling times for the lock that were derived from head differentials from various synthetic rainfall events in 81 storage areas. When sizing the culvert gates, using the entire existing Calcasieu model proved to be impractical, so the model was reduced to the section of the GIWW just east of the LA 384 pontoon bridge and the new proposed drainage channel. This allowed actual upstream and downstream adjusted elevations to be used for boundary conditions over a 4-year period. Since the sill elevation of the existing 75-foot wide lock is at -13.0 feet NAVD 88 and the maximum estimated water surface elevation is +3.0 feet, the estimated cross sectional area is simply 16 feet times 75 feet, or 1200 square feet. Due to structural and cost constraints, the proposed gates were limited to 14 feet wide by 9 feet tall, so nine gates would closely approximate the 1200 square feet of area required, assuming the same slope. Optimizing for cost, further study was done and seven gates were proved sufficient. This design was tested with the actual stages from 04SEP2009 to 27DEC2013 and also verified to be within the limits of a different 10-year synthetic rainfall event.

The proposed channel is approximately 4500 feet in length with a 120-foot width at the sill elevation of -12.0 feet NAVD 88 and side slopes of 1V:3H. Material will need to be excavated and placed in the areas designated for marsh restoration. Seven gates measuring 14’ wide by 9’ tall will be centered with 2 feet of spacing between them at a bottom elevation of -6.0 feet NAVD 88. Figure L-40 shows the proposed channel.

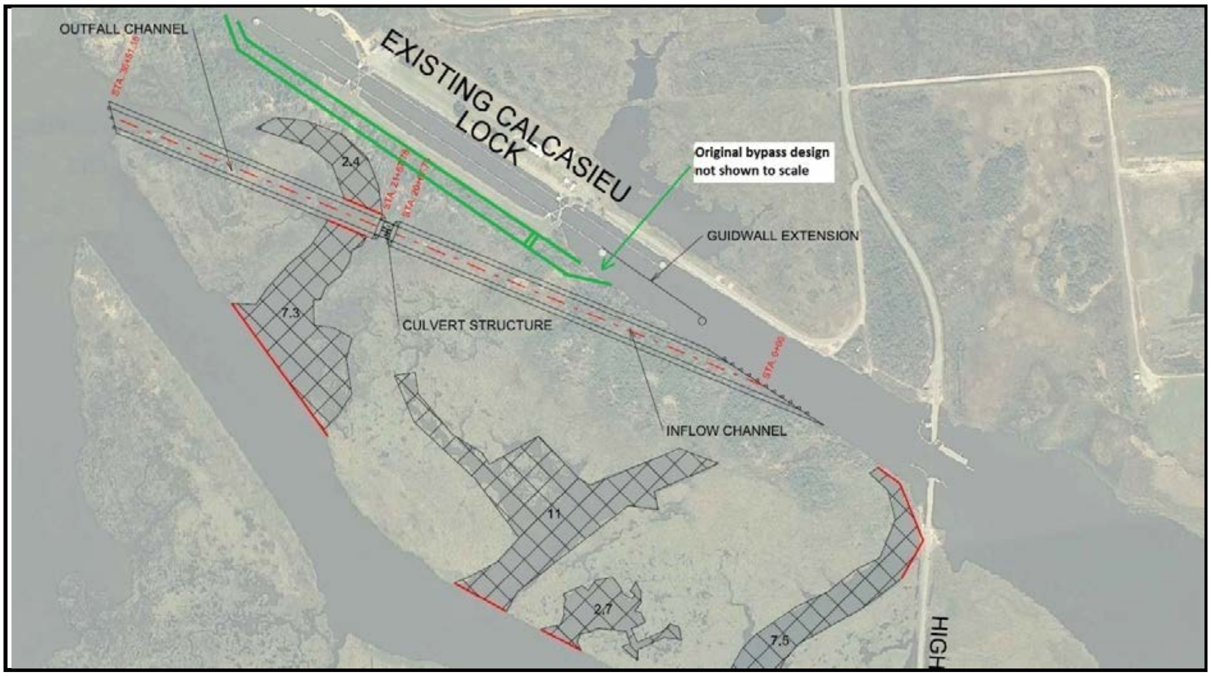

Figure L-40. Plan View of Proposed Gated Drainage Culvert and Channel

The typical channel cross section with the 120-foot wide bottom is shown below in figure L-41, which are all sections beyond the 600-foot distances from the culverts.

The original gate configuration was a 75-foot width by 15-feet tall, set at a sill elevation of -12 feet NAVD 88. This was simply too costly and impractical for daily use, so the team suggested a sill elevation of -6.0 feet and a maximum width of 14.0 feet per gate, while adding as many gates that were needed. Seven gates were tested in the HEC-RAS model and the results were acceptable. The next step was to taper the cross sections of the channel to fit the culverts most efficiently. A cross section and profile of this result is shown in figure L-42. Note that the bottom width increases from 120 feet at the 600-foot upstream and downstream distances to 156 feet wide at the sill elevation of the culverts.

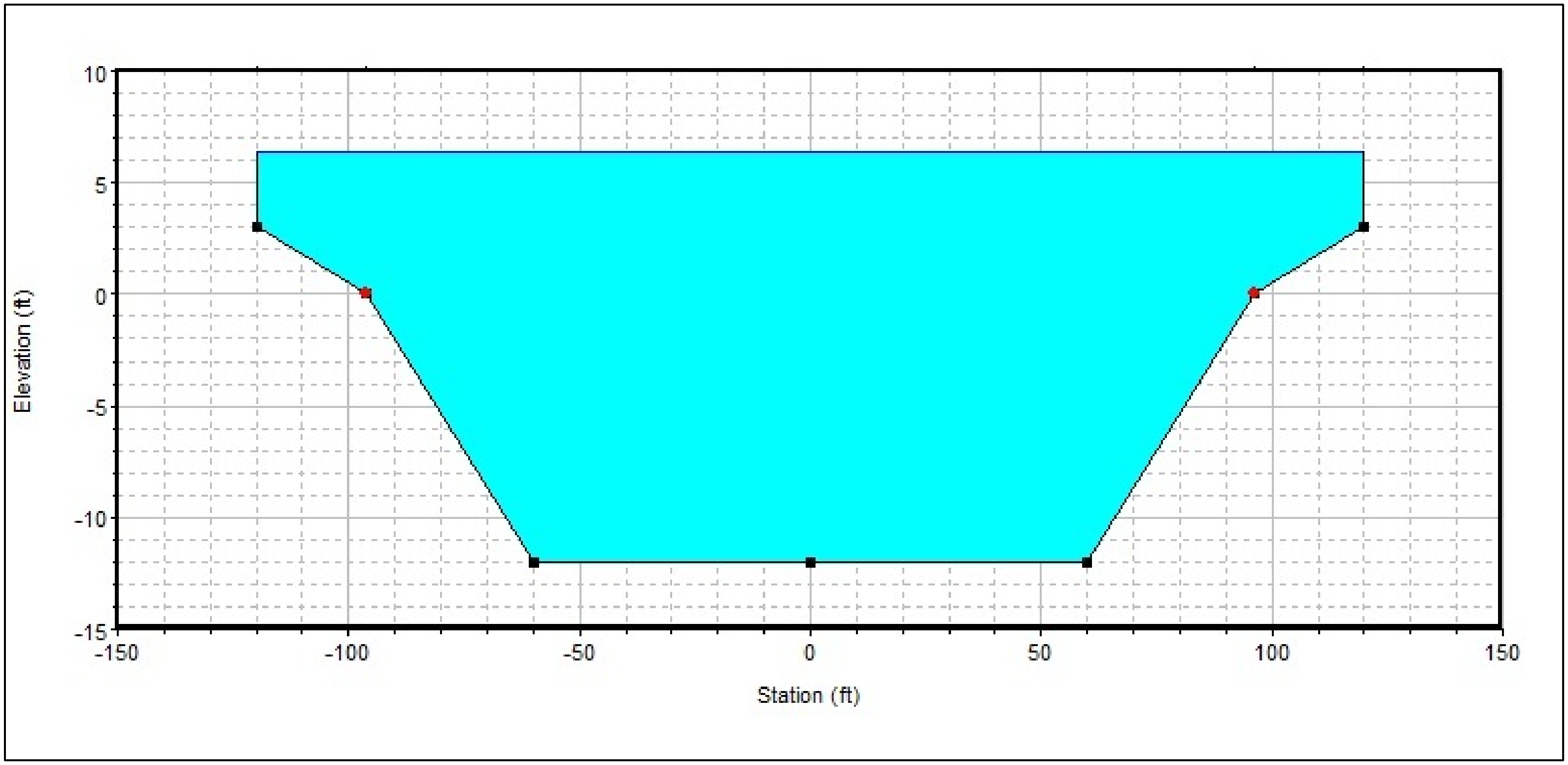

Figure L-41. Typical Cross Section of Main Channel Beyond the Sloping Sections to the Culverts

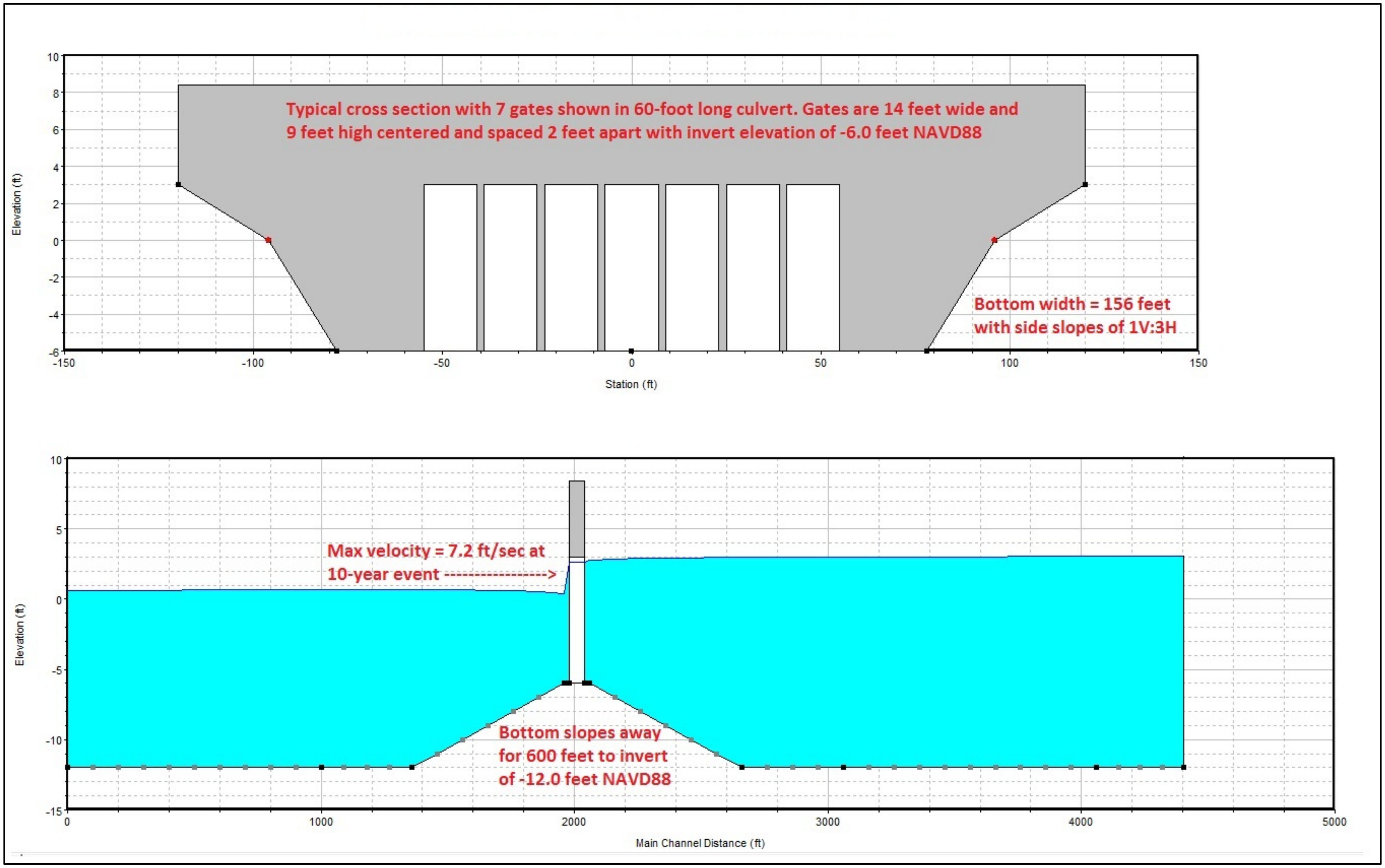

Figure L-42. Culvert Cross Section and Channel Profile for Proposed Flow Diversion

A plot of how the flow from the existing lock is mimicked by either 7 gates or 6 gates is shown in figure L-43. Notice that six gates would have been unacceptable because not enough flow was diverted from the existing lock.

The flows for the nine-gated design are shown in figure 6. Notice that flows for this design exceed that of the existing lock for 98% of all cases in the same time period as figure L-44, sorted by high flow to low flow of the existing lock.

Since the focus from head differential analysis at the existing lock was changed to diverting equivalent flow from the existing lock, a check was made between the 9-gated culvert first recommended and the 7-gated culvert optimization. Figure L-45 compares head differentials at the existing lock between the two different gate designs.

D. Results and Conclusions. Using average locking times for the existing lock and comparing head differentials for different gate configurations proved to have much more promising results. Figure L-46 shows the results comparing gates numbering 0 (existing conditions), 7, and 9. Based upon the analysis period of 04SEP2009 to 27DEC2013, whenever inland stages were higher than gulf side stages, the proposed culvert with seven gates would have saved anywhere from 39% to 100% of the existing positive head differentials at the lock, with an average of 65% savings. Adding another two gates to this culvert would not improve these percentages enough to justify the higher cost of nine gates. Therefore, seven gates will provide sufficient drainage as required.

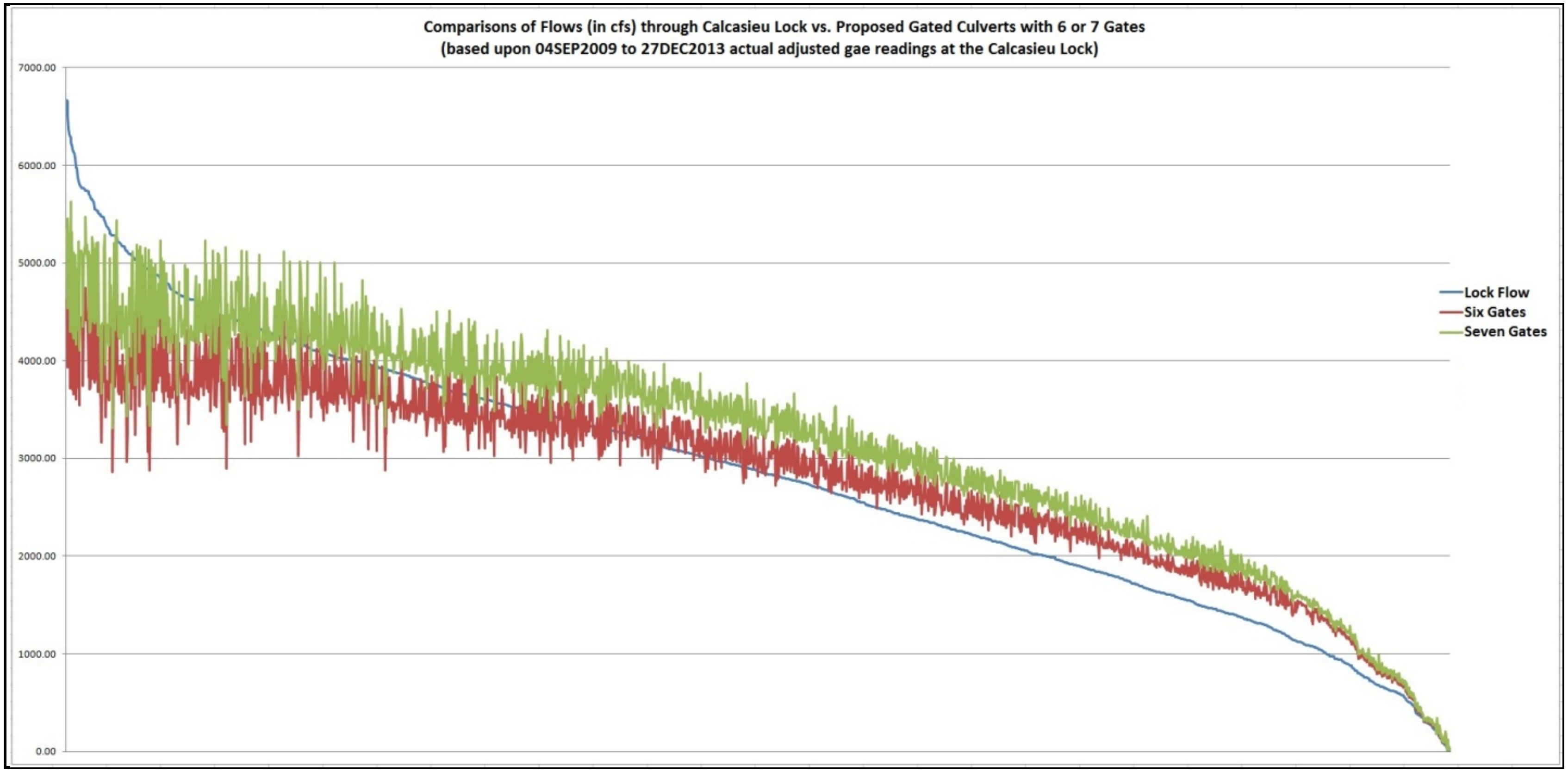

Figure L-43. Flow Comparisons Sorted by High Flow to Low Flow of Existing Lock

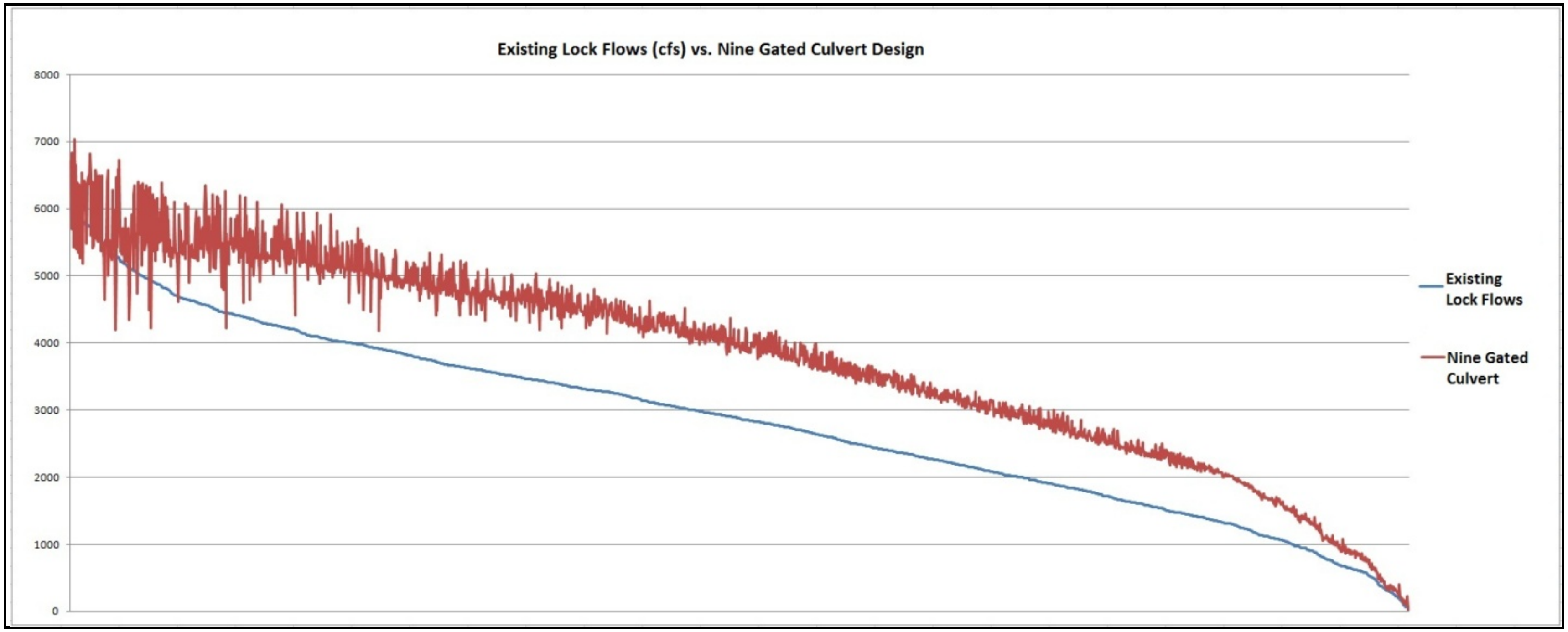

Figure L-44. Flow Comparisons for the Nine Gated Culverts

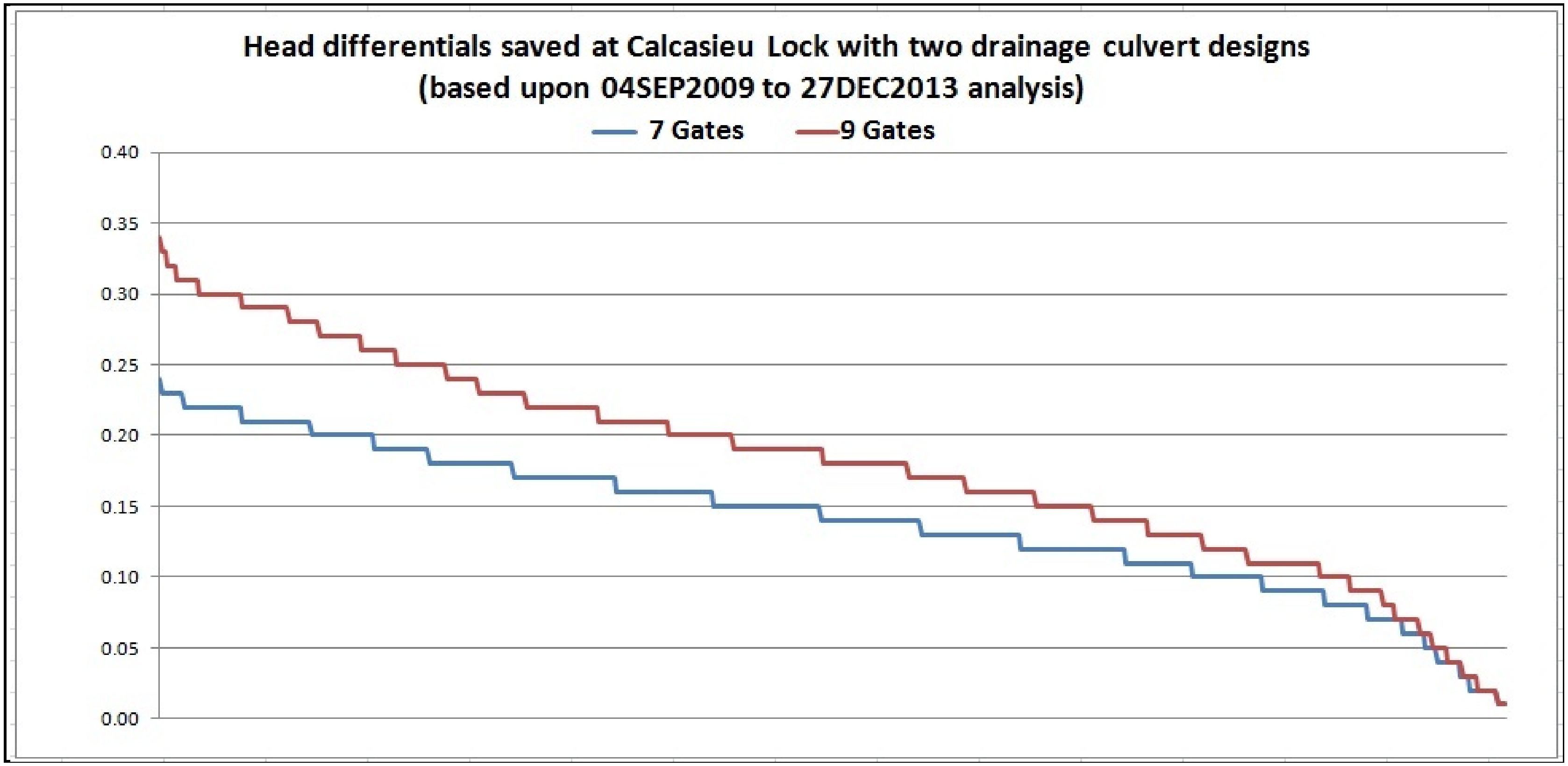

Figure L-45. Head Differentials at Calcasieu Lock Sorted by Highest Head to Lowest Head

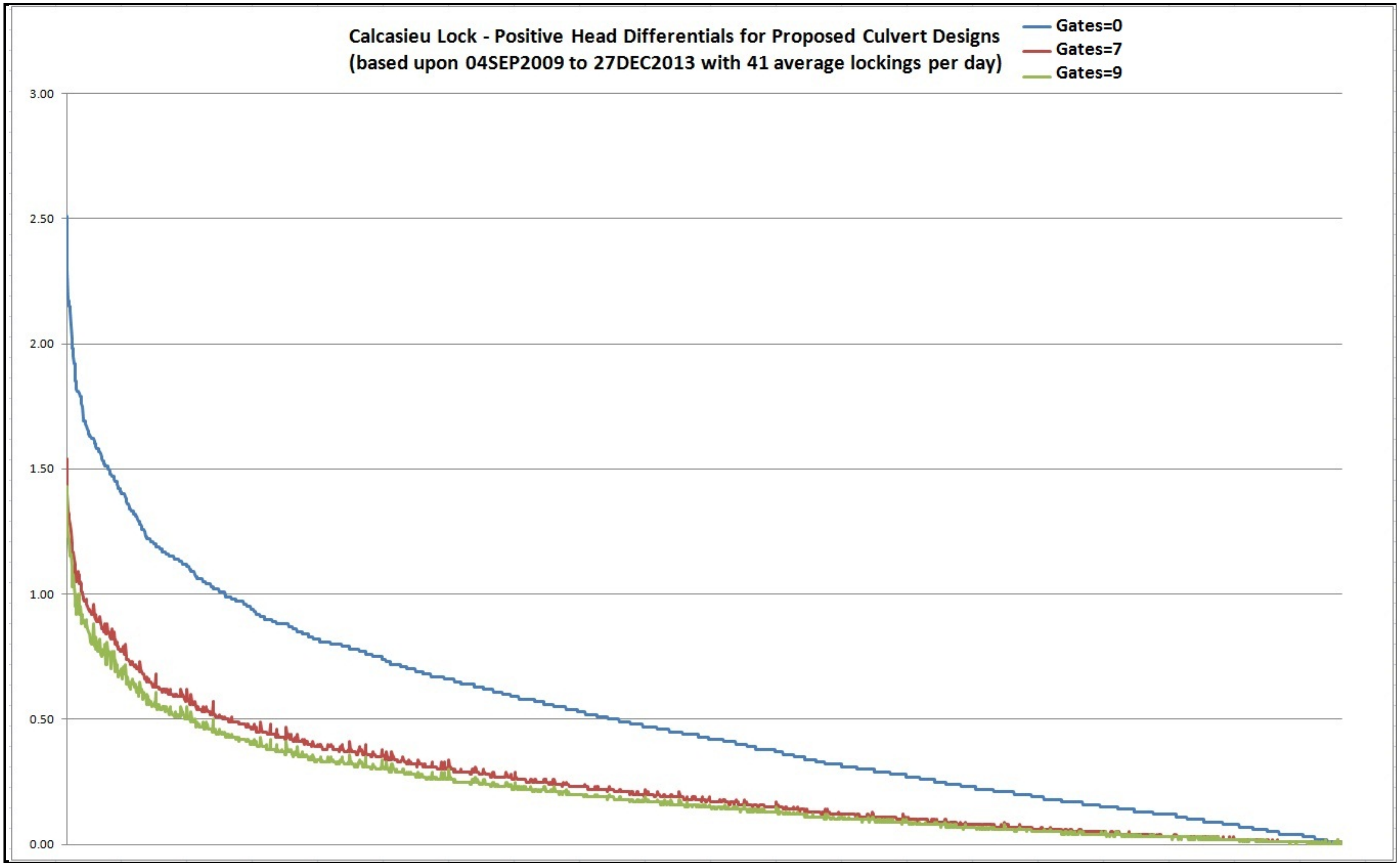

Figure L-46. Comparisons of Head Differentials at East Lock Gates for Proposed Culvert with Average Daily Lockings, Sorted by High Flow to Low Flow from 04SEP2009 to 27DEC2013

E. Rip Rap Design. From Section 3. 6 of the FHWA hydraulics publication HEC11SI, the rip rap extent can be determined as one channel width. Specifically quoted from this document: "If the control point does not cause significant flow contraction, or there is no significant flow expansion downstream of the control, the bank revetment should be terminated approximately one channel width downstream of the control. However, if significant flow contraction and/or expansion is occurring in the vicinity of the control, the protection should be continued downstream for a distance equal to four times the constricted channel width at the control. "

The rip rap thickness was obtained from the Isbach Calculation and resulted in a minimum thickness of 21 inches placed in dry conditions. Since some of the rip rap may be submerged during construction, another 10.5 inches is recommended to yield a 31. 5 inch thickness, rounded up to 36 inches.

On each side of the channel on both intake and outflow, the dimensions of each of the 4 sections will be 200 feet long X 1. 75 feet thick, with the height 21 feet at the structure and 27 feet 200 feet away from the structure. It will be placed on each slope and starting at sill elevation of -6.0 feet NAVD88 at the structure to -8.0 feet NAVD88 at the 200 foot distance. It will build up 2.0 feet past the bank elevation. In addition, another section measuring 156 feet wide by 200 feet long will need to be laid on the channel bottom on the outfall west side only. Once all rip rap has been placed, the outflow west side slopes will need to be grouted to prevent destruction from frequent tropical systems.

The stone gradation for dry placement will be 60-140 lbs. at 100% lighter by weight, 30-60 lbs. at 50% lighter by weight, 10-30 lbs. at 15% lighter by weight. This is a 21 inch layer.

The stone gradation for wet placement will be 260-650 lbs. at 100% lighter by weight, 130-260 lbs. at 50% lighter by weight, 40-130 lbs. at 15% lighter by weight. This is a 36 inch layer.

Since the channel bottom slopes away from the structure from -6.0 feet NAVD88 elevation to -12.0 feet NAVD88 at a distance of 600 feet on either side of the culverts, sedimentation is not to be expected.

III. CIVIL DESIGN

Approximately 3,650 linear feet of dredging for the inflow and outflow channels will be required to tie the GIWW to Bayou Choupique. This channel, constructed by hydraulic dredging, is approximately 200 feet wide at the top. The channel will be dredged to elevation (-) 12.0 NAVD88 and have a 120 foot bottom width, and 1V on 3H side slopes. The channel will transition to -6.0 NAVD 88, with a channel bottom width of 150 feet at the structure. The transition will occur over 600 ft east and west of the structure at a 1V on 100H slope (approximately 215,000 cubic yards). Dredged material would be placed within the project area in areas of open water totaling about 50 acres. Placement of dredged material into these disposal sites is intended to convert open water to estuarine marsh. For disposal of dredged materials, a pipeline will be routed through the existing open water using floating and/or submerged pipeline.

IV. STRUCTURAL DESIGN

A. General. A gated water control structure would be constructed inside the channel to control the passage of freshwater flows. The culvert structure consists of seven openings (9' x 14' each) that will allow for the passage of the additional flow. The structure is a pile-founded reinforced concrete box culvert with stainless steel sluice gates. Seepage cutoff sheet piling will be placed along the entire width of the structure. The sluice gates will remain in the open position to drain the Mermentau Basin and can be closed when salinity levels in the Ship Channel exceed the allowable limits. The structure foundation consists of 50-ft long pre-stressed concrete piles. The structure is 114-feet wide and 110-feet long. The invert of the structure is (-)6.0, with the top of the culvert structure at (+)5.0.The top of the gate tower is at (+)14.0 NAVD88. The top of the culvert is higher than the anticipated flow line thru the area, so water cannot overtop the structure. The structure is placed in an area along the by-pass channel where the natural ground is above elevation (+)4.0 NAVD88, so water cannot flank the structure during drainage events. For this phase of the project, trash screens were considered to prevent large debris from clogging the culverts, which can prevent the gates from fully closing. Since these trash screens will need to be cleaned by equipment from barge or from land access, this assumption will be further evaluated in the PED phase with Operations Division.

Riprap will be placed 200-feet on either side of the structure, only on the side slopes of the inflow and outflow channels. 50-feet of riprap will be placed on either side of the structure, along the channel bottom.

Steel bulkheads (stoplogs) will be provided so the structure can be dewatered for maintenance purposes. The bulkheads can be placed on either side of the gate tower to isolate the area from the rest of the structure.

The sluice gates have electric motors that will be operated either locally at the structure, or remotely at the Calcasieu Lock. Closed-circuit cameras will be provided at the structure for lock personal to inspect the gate operations. Therefore, there is no requirement to man the structure during events in which the structure is opened.

Timber pile clusters will be constructed where the by-pass channel intercepts the GIWW and Bayou Choupique. The clusters are provided to prevent barge access into the by-pass channel.

Figure L-47 shows the pan view of the culvert structure and figure L-48 shows the section view of the culvert.

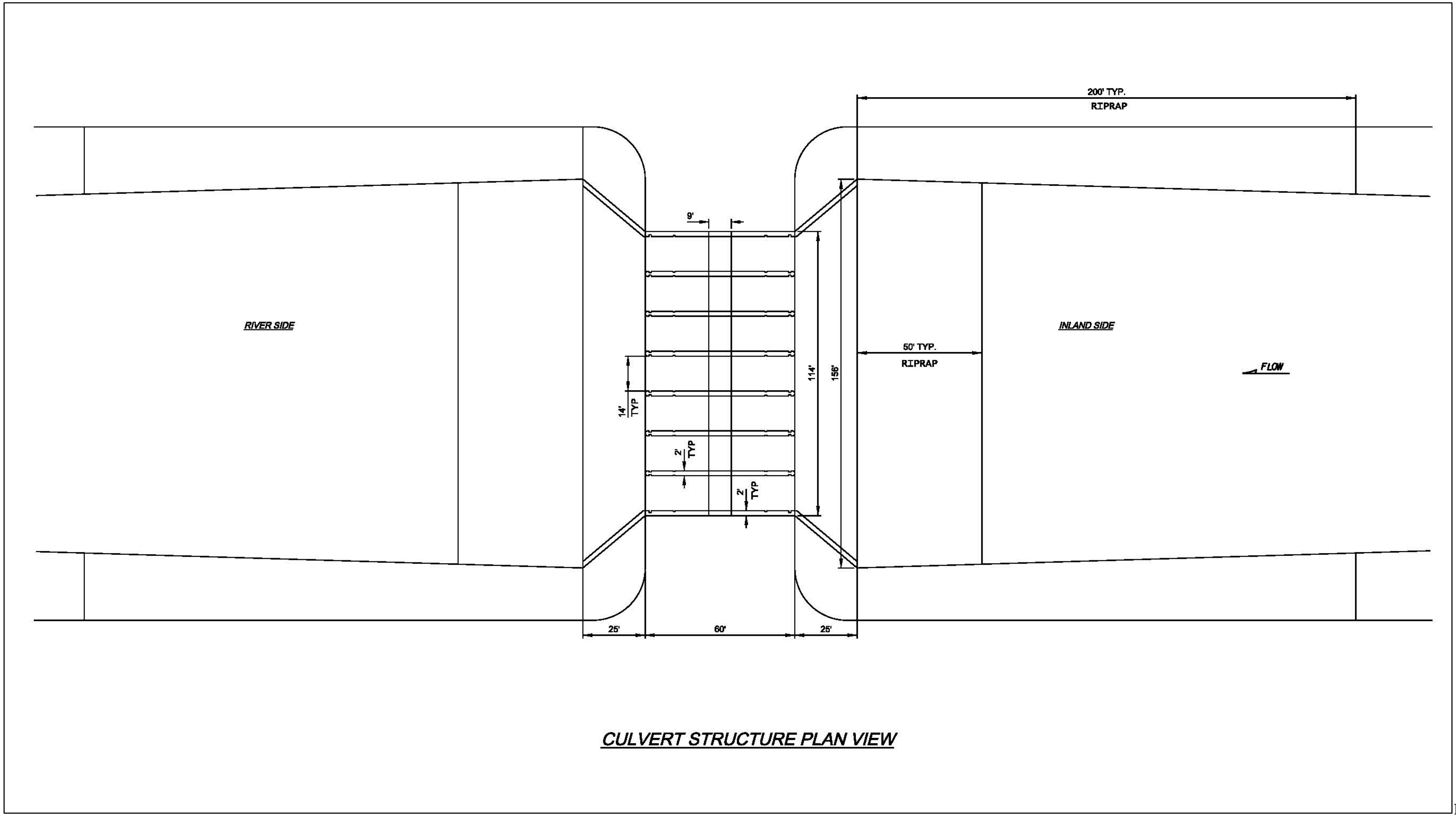

Figure L-47.

Figure L-47. Plan View Culvert Structure

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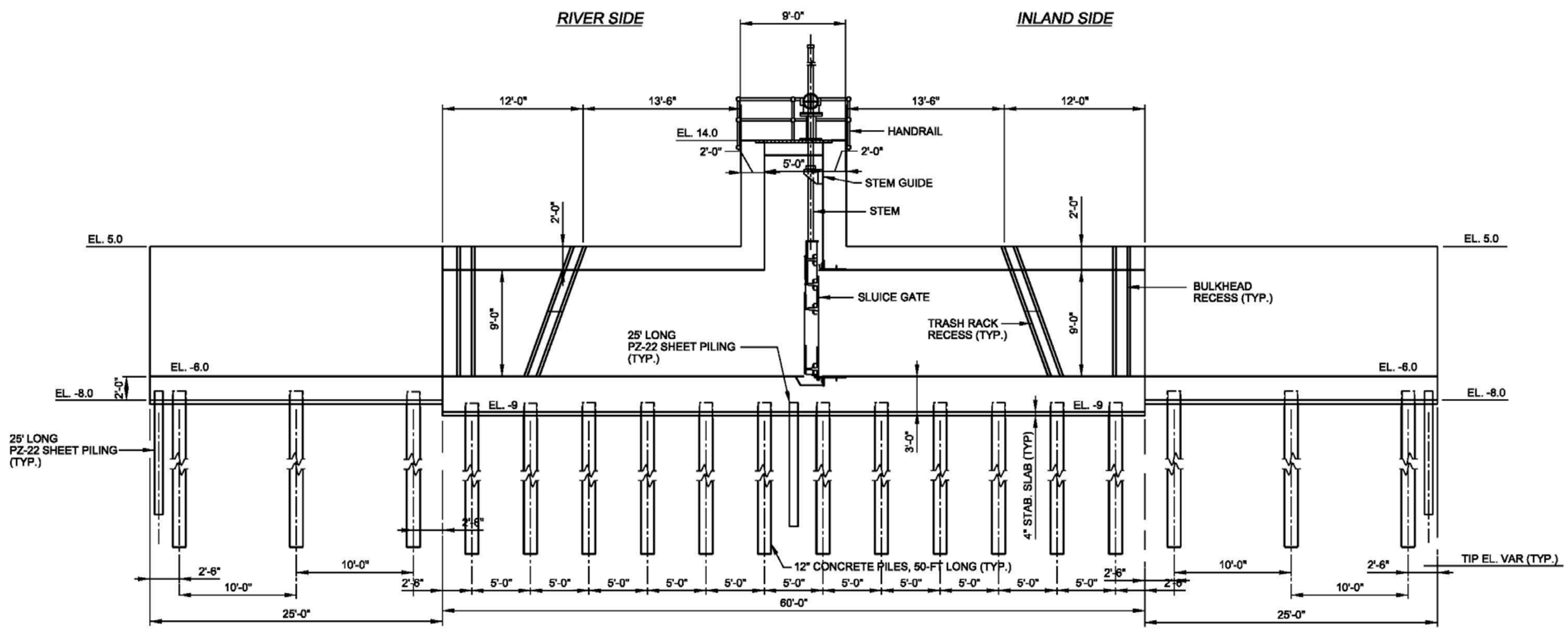

CULVERT STRUCTURE SECTION

Figure L-48. Section View Culvert Structure

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B. Hydraulic Design Criteria

Design Water Conditions	River Side Elevation in Feet NAVD 88 (2004. 65)	Inland Side Elevation in Feet NAVD 88 (2004.65)
Normal	0.0	0.0
Drainage Condition	+1.0	+3.0
Storm Condition	+3.0	+1.0

For design of culvert and riprap, refer to Hydraulic Section.

C. Structural Design Criteria. The permanent and temporary features of the project shall be designed in accordance with applicable portions of Corps engineering manuals for civil works construction and applicable portions of industry codes. All designs shall be based on established engineering practices, incorporating advanced technology when it has been demonstrated that such technology gives safe and efficient designs.

Reinforced Concrete Design Criteria. Cast-in-place concrete design strength shall be 4,000 psi strength. Prestressed concrete design strength shall be a minimum of 6,000 psi for concrete piles.

Steel Design Criteria. The Allowable Stress Design (ASD) method shall be used for steel structures and not the Load and Resistance Factor Design (LRFD) method. The allowable stress = 5/6 of AISC allowable stress. The American Welding Society, AWS D1. 5 (2002) code shall be used for fracture critical members. Welded structures should be welded all around (seal welded). Welds shall be designed and not simply made full penetration as the cost and residual stresses imparted by unequal cooling are detrimental. All steel will be constructed from material conforming to ASTM A-572 Grade 50.

Steel Reinforcing. Steel reinforcing shall be ASTM A615 Gr. 60 with fy = 60 ksi, Steel reinforcing for prestress concrete shall be Grade 270 strands (270,000 psi).

Load Factors. Single load factor of 1. 7 for dead and live load shall be used in addition to a Hydraulic factor. Hydraulic factor of 1. 3 shall be applied to both shear and moment. The hydraulic factor is used to improve crack control in hydraulic concrete structures by increasing reinforcement requirements, thus reducing steel stresses. Strength reduction factor for bending shall be 0.9. Strength reduction factor for shear shall be 0.85.

General Load Case Table. See table L-10

Table L-10. General Load Case Table
(general load case tables used to design structure

LC	Overstress Allowed		Load Case Name	Description
	Foundation	Wall		
LC 1	16⅔%	16⅔%	Construction	Dead Load, 200 Psf Equipment
LC 2	33⅓%	33⅓%	Construction + Wind	Dead Load, 200 Psf Equipment, Wind One
LC 3	0	0	Normal Water	Dead Load, No Wind
LC 4	33⅓%	33⅓%	Normal Water + Wind	Dead Load, Wind from One Side
LC 5	0	0	Drainage	Dead Load, No Wind
LC 6	33⅓%	33⅓%	Drainage + Wind	Dead Load, Wind from One Side
LC 7	0	0	Dewatered	Dead Load, Uplift
LC8	33⅓%	33⅓%	Storm	Dead Load, Wind

Note: Storm load condition is a short term differential load condition since the culvert structure is not intended to serve at flood protection. Water levels will eventually balance as the areas around the structure are overtopped from storm surge.

D. Culvert Structure Foundation Design

Piling – General. The pile foundation for the culvert structure will include vertical 12" prestressed, precast concrete piles. The design Factors of Safety utilized for the design comply with EM 1110-2-2906 and the latest requirements in the HSDRRS design guidelines. Tension hooks are provided on all piles to handle the maximum tensile load.

CPGA Analysis. CPGA was utilized to develop the pile layout for the culvert structure and determine the required tip elevation. The piles were modeled as pinned connections with the piles providing all of the lateral resistance. The horizontal subgrade modulus was based on the soil in the top ten pile diameters. The horizontal subgrade modulus was reduced for group effects in accordance with EM 1110-2-2906.

Pile Curves and Horizontal Subgrade Modulus. Pile curves and horizontal subgrade modulus were calculated for a limited number of pile types. Refer to Geotechnical portion of the Appendix for pile curves.

Cut-off Wall. A cut-off sheetpile wall will be provided to reduce possible seepage and scouring. A PZ-22 sheetpile meeting the requirements of ASTM A572, Grade 50 was assumed for the cutoff walls. Tip elevations were estimated based on anticipated soil stratification. Tip elevations will be finalized when borings at the site are completed. Elevations will be provided by New Orleans District Engineering Division Geotechnical Branch utilizing Lane's Weighted Creep Ratio at the structure.

E. Culvert Structure Design

Sluice Gate Walls. The breast walls were designed for the hydrostatic pressure differential above the sluice gates, fixed between the pier walls. A portion of the load from the hydraulic cylinder and walkway were also placed on the breast wall, but were not examined because the breast wall functions as a very deep beam with a large capacity in the plane that the hydraulic cylinder load is applied. A 2-ft thick breast wall was used for all sluice gate structures.

The operating platform beams were designed for the dead and live loads imparted by the sluice gate and its machinery as well the dead and live loads from the operating platform. The beam was designed as fixed between the pier wall supports. A 2’ wide by 2’-6” deep operating platform beam was used for culvert structure. The pier walls were designed as a wall with the combined axial load and moment imparted by the breast walls, operating platform beam, and lateral load from a dewatered condition. The pier wall design section was set equal to the thickness of the pier wall with loads extended through the depth of the wall at a 45 degree angle. An interaction diagram was setup to verify that the ultimate moment and compression were within the allowable limits. The pier wall was assumed as a cantilever to determine the moments associated with the dewatering loads. The live and dead load moments from the breast walls and operating platform beam were taken assuming those beams are fixed at the pier walls. A 2-ft thick pier wall was used for the culvert structure.

Sluice Gate Base Slab. The sluice gate base slab thickness was determined utilizing a 2D strip with a width equal to the width of one sluice gate bay. The strips were designed as solid beams, given the property of the width of the slab that was examined. All loads acting along the width of the beams were input into Structural Analysis and Design and resolved along the centroid of the beam. Piles were modeled as pinned supports. A 3-ft base slab thicknesses was used for the culvert structure.

Sluice Gates. The sluice gates will be pre-manufactured 14’x9’ stainless steel gates.

Sluice Gate Bulkheads. The sluice gate bulkheads are designed to dewater portions of the structure to permit maintenance of the sluice gates and concrete gatebay. For estimating purposes, bulkheads of similar sized were used.

The bulkheads will be designed for a sill elevation of -6.0 with a water elevation of +3.0.The culvert structure will be provided with 4 bulkheads, permitting the dewatering of 2 sluice gate bays at a time.

The steel bulkheads typically consist of horizontal L8x4x1/2 members with a 3/8” skin plate. The skin plate will be designed conservatively as a simply supported member between the horizontal angles. The horizontal angles will be designed as simply supported members between the sluice gates walls. The skin plate will be considered as an effective part of the horizontal angles, with the effective width of skin plate determined according to the AISC specifications for a non-compact flange.

For this phase of the report, it was assumed placement of bulkheads will done using barge mounted cranes. Further investigation into the dewatering bulkheads with Operations Division will done during the PED phase regarding the logistics for placement of the bulkheads.

F. Miscellaneous Features

Timber Pile Clusters. Timber pile clusters will be provided as aids to navigation and to protect the structure from impact. Details were taken from historical timber pile clusters constructed in New Orleans District rather than performing actual design on this component.

Access Road. An access road will be provided from the Calcasieu Lock to the culvert structure. The access road will be 10-ft wide and consist of stone bedding. A fabric will be placed beneath stone bedding. The road will allow access for small vehicles (ATV, Mules, etc.). Large vehicular traffic is not anticipated since the structure is on the non-traffic side of the lock.

G. Electrical Design

Electrical Service. The power both utility and backup power for the structure will be provided from the Calcasieu Lock. The service will be sized to support the structure loads including power for Gate machinery, lighting, controls, and any other miscellaneous loads. This assumes that the Lock has enough capacity to support additional load for sluice gates.

Grounding System. The structure grounding system will be in accordance with the NFPA 70 - National Electrical Code. The grounding system will consist of copper ground rods interconnected with copper conductors. All jumpers and grounding electrode conductor connections will be done by exothermic weld. All electrical equipment, machinery, and exposed metal will be bonded to the grounding electrode system.

Lighting System. All exterior lighting fixtures will be provided with vandal-proof shields. The fixtures will be HPS and shall be controlled by photocells.

Conduit and Boxes. All wiring will be installed in rigid metal conduit except that motors and other electrical equipment subject to vibration will be connected with liquid-tight flexible metal conduit. All pull boxes and junction boxes will be of cast metal of sufficient thickness or provided with bosses to accommodate the required threads for the conduit connections of size specified. All outlet boxes for receptacles, switches, and lighting fixtures will be of cast metal with bosses drilled and tapped or with threaded hubs of sizes specified. The edges will be designed to take a heavy cover gasket with four or more screws for attaching covers or fixtures.

Controls. A hard wired control system will be installed to operate the Gates. The control console will be installed in the control house at Calcasieu Lock. Additionally, local controls will be provided at each sluice gate.

Lightning Protection System. A lightning protection system will be designed to protect the structure from lightning strikes. The system will be designed in accordance with NFPA 780-Installation of Lightning Protection Systems. Surge suppression devices on all incoming power and communication lines will be provided.

Closed Circuit Cameras. A closed circuit system will be installed at the sluice gate structure to view and operate remotely from Calcasieu Lock. The system consists of cameras, fiber optic cables, and transceivers. The cameras will be connected to existing CCTV system at the Lock.

H. Mechanical Design

Sluice Gate Operation. Sluice gate operation will be to raise, lower, or hold the sluice gate in intermediate positions to allow, prevent, or meter drainage water flow and to prevent backflow during salinity events. Operating time was designed to be less than fifteen minutes to fully raise or lower each sluice gate.

Sluice Gate Operating Loads. The sluice gate operating loads consist of friction from the stem, sluice gate weight, stem weight, hydrodynamic loads. The hydrodynamic loads were developed from differential hydrostatic head applied over the sluice gate.

Sluice Gate Operating Machinery. The sluice gate operating machinery will be an operating stem, bevel gearbox, and electric actuator. The operating stem will be attached to the top of the sluice gate within the stem pocket. The operating stem will be machine threaded AISI 316 stainless steel. The aluminum bronze ASTM B505 lift nut within the bevel gearbox will be machine threaded to mate with the AISI 316 stainless steel operating stem. The electric actuator will mount onto the bevel gearbox used to rotate the operating stem to raise or lower the sluice gate. The electric actuator considered for the 14’x9’ sluice gates was a 10 horsepower Biffi Icon 2000 040/720-173.

V. COST ENGINEERING

A. General. The project cost estimate was developed in the TRACES Mii cost estimating software and used the standard approaches for a feasibility estimate structure regarding labor, equipment, materials, crews, unit prices, quotes, sub- and prime contractor markups. This philosophy was taken wherever practical within the time constraints. The Mii estimate can be found in the Cost Annex to this appendix. It was supplemented with estimating information from other sources where necessary such as quotes and bid data. The intent was to provide or convey a “fair and reasonable” estimate that which depicts the local market conditions. The estimates assume a typical application of tiering subcontractors. Given the long time over which this project/program can be constructed and the unknown economic status during that time, demands from non-governmental civil works projects were not considered to dampen the competition and increase prices.

Estimate Structure. The estimate is structured to reflect the projects performed. The estimates are subdivided by USACE feature codes.

Bid competition: It is assumed that there will not be an economically saturated market and that bidding competition will be present.

Contract Acquisition Strategy. It is assumed that the contract acquisition strategy will be similar to past projects. Award to a small business/8(a), and large, unrestricted design/bid/build contracts is possible. There is no declared contract acquisition plan/types at this time, so typical MVN goals have been included.

Labor Shortages. It is assumed there will be a normal labor market.

Labor Rates. Local labor market wages are above the local Davis-Bacon Wage Determination and actual rates have been used. This is based upon local information and payroll data received from the New Orleans District Construction Representatives and estimators with experiences in past years.

Materials: Cost quotes are used on major construction items when available. Recent quotes may include borrow material, concrete, steel and concrete piling.

Assumptions include:

a. Materials will be purchased as part of the construction contract. The estimate does not anticipate government furnished materials. Prices include delivery of materials.

b. Concrete will be purchased from commercial batch plants.

c. Piling quantities is considered the highest risk in the contract. These quantities can be finalized upon the completion of borings. It is the PDT’s contention that the footprint and piling lengths are conservative and that changes to quantities would be reduced.

The borrow quantity calculations followed the MVN Geotechnical guidance:

Hauled Levee: 10 BCY of borrow material = 12 LCY hauled = 8 ECY compacted.

An assumed average one-way haul distance of 10 miles was used unless a committed borrow source has been confirmed available. This decision is based upon discussions with the New Orleans District cost engineers and Calcasieu Lock PDT.

Haul speeds are estimated using 30 mph speed average given the long distances and rural areas.

d. Rock and Stone. The New Orleans delta area has no rock sources. Historically, rock is barged from northern sources on the Mississippi River. This decision is based upon local knowledge, experience and supported with cost quotes.

Equipment: Rates used are based from the latest USACE EP-1110-1-8, Region III, 2009. Adjustments are made for fuel, filters, oil and grease (FOG) prices and facility capital cost of money (FCCM). Judicious use of owned verses rental rates were considered based on small business, large business and local equipment availability.

- ***a. Trucking.*** The estimate assumed the prime contractor can handle earthen material hauling.
- ***b. Dredging.*** The approach channel dredging was accomplished using a subcontractor .
- ***c. Electrical.*** Installation of electrical items of work were performed by a subcontractor.
- ***d. Severe Rates.*** Severe equipment rates were used where appropriate.

Fuel: Fuels (gasoline, on and off-road diesel) were based on local market averages for on-road and off-road. The Team found that fuels fluctuate irrationally; thus, used an average.

Crews: Major crew and productivity rates were developed and studied by senior USACE estimators familiar with the type of work. All of the work is typical to the New Orleans District. The crews and productivities were checked by local MVN estimators, discussions with contractors and comparisons with historical cost data. Major crews include haul, earthwork, piling and concrete.

Tugs: Tug boat rental rates are developed from quotes provided by vendors in the MVN region. Allowances for fuel and lubrication are added based upon the working status of the equipment. Full throttle or less than full throttle are the two work statuses of the equipment considered. Labor is included in the rental rate provided. The tug boats described in CEDEP with the dredge are contractor owned tugs. The value of the equipment had been determined from canvassing the market for similar equipment and the monthly cost is determined based upon the procedures outlined in EP 1110-1-8, Volume 3, November 2011. Rental tugs are used with CEDEP for mobilization of the dredge and pipeline.

Unit Prices: The unit prices found within the various project estimates will fluctuate within a range between similar construction units such as floodwall concrete, earthwork, and piling. Variances are a result of differing haul distances (trucked or barged), small or large business markups and sub-contracted items.

Relocation Cost: No relocation costs are anticipated with the current project scope.

Mobilization: Contractor mobilization and demobilization are based on the assumption that many of the contractors will be coming from within a 500 mile radius. The estimate assumes work camps (housing, trailers and equip), utility hookups, equipment, trucks and trailers, superintendent, foremen, operators, and skilled trades where necessary. Based on historical studies, Pre-Katrina detailed Government estimates for mobilization averaged 4. 9 to 5% of the construction costs. The estimate utilizes the approx. 5% value at each contract. The 5% value matches well with the 5% value prescribed by Walla Walla District, which has studied historical rates.

Dredging mobilization is based on the assumption of a 300 mile distance by marine conveyance. This is a common distance reflecting the gulf coast area and is very conservative for the size dredge selected.

Field Office Overhead: The estimate used a calculated field office overhead rate of 6% for the prime contractor. This is determined on a construction schedule of 9 months for the entire project. Overhead assumptions include superintendent; office manager; pickups; periodic travel; costs; communications; temporary offices (contractor and government); office furniture; office supplies; computers and software; as-built drawings and minor designs; tool trailers; staging setup; work camp and kitchen maintenance and utilities; utility service; toilets; safety equipment; security and fencing; small hand and power tools; project signs; traffic control; surveys; temp fuel tank station; generators; compressors; lighting; and minor miscellaneous. The dredging field office overhead is included in CEDEP and not described as a percentage in Mii.

Home Office Overhead: Estimate percentages range based upon consideration of 8(a), small business and unrestricted prime contractors. The rates are based upon estimating and negotiating experience, and consultation with local construction representatives. Different percents are used when considering the contract acquisition strategy regarding small business 8(a), competitive small business and large business, high to low respectively. The applied rates were previously discussed among numerous USACE District cost engineers including Walla Walla, Vicksburg, Norfolk, Huntington, St. Paul and New Orleans.

Taxes: Local taxes will be applied, using an average between the parishes that contain the work. Reference the LA parish tax rate website: http://www.laota.com/pta.htm

Bond: Bond is assumed 0.75% applied against the prime contractor, assuming large contracts. The electrical subcontractor uses a bond of 1. 4% and the dredging subcontractor uses a bond of 1%.

E&D and S&A: USACE Costs to manage Planning, Engineering & Design (PED) and Supervision & Administration construction (S&A) are based on New Orleans District Programmatic Cost Estimate guidance:

> ***a. PED.*** The PED cost includes such costs as project management, engineering, planning, designs, investigations, studies, reviews, value engineering and engineering during construction (EDC). Historically New Orleans District has used an approximate 10% rate for E&D/EDC, applied against the estimated construction costs. Other USACE civil works districts such as St. Paul, Memphis and St. Louis have reported values ranging from 10-15%. Additional costs were added for project management, engineering, planning, designs, investigations, studies, reviews, value engineering.
>
> ***b. S&A.*** Historically, New Orleans District used a range from 5% to 15% depending on project size and type applied against the estimated construction costs. Other USACE civil

works districts such as St. Paul, Memphis and St. Louis report values ranging from 7. 5-10%. Consideration includes that a portion of the S&A effort could be performed by contractors. Based on discussions with MVN Construction Division, an S&A cost of 8.0% was used.

B. Contingencies. Contingencies were developed using the USACE Abbreviated Cost Risk Analysis (CSRA) process. The PDT met on 20 February 2014 to discuss the risk associated with this project. Nine folders from the MII were analyzed for risk. The main contributors to risk are Care and Diversion of Water, Foundation Work and Seepage Control. Soil conditions and a more refined design could alter the current quantities. Combining these three risk factors with the remaining factors a contingency of 19.09% was developed. To mitigate these risk in the planning engineering design phase more information will be obtained to determine final construction quantities. Elements of Real Estate Division provided contingency of 32% for base real estate cost. The abbreviated CSRA can be found in the Cost Annex.

C. Construction Schedule. A construction schedule has been developed and can be found in the Cost Annex. The first order of work is Mobilization, clearing and grubbing and the construction of an access road. Dredging operations can begin and are done concurrently with cofferdam construction and structural excavation. After cofferdam construction and structural excavation foundation piles are driven which can be executed concurrently with seepage control operations. After piling operations are complete concrete placement can begin. After concrete is placed slide gates, embedded metal work and electrical and mechanical features of work can proceed. Pile cluster and riprap can be placed after dredging is completed. Cofferdam removal can occur when the structure is completed and demobilization operations can begin.

D. Escalation. Escalation is based upon the USACE Engineering Manual 1110-2-1304 Civil Works Construction Cost Index System revised 30 Sep 2013.

E. Cost Estimate. Table L-11 shows the February 2014 baseline project cost. This information is taken from the Total Project Cost Sheet in the Cost Annex.

Table L-11 Baseline Cost

Feature	Cost	Contingency	Total
01 Lands & Damages	$95,000	$33,000	$128,000
02 Relocations	N/A	N/A	N/A
06 Fish & Wildlife Facilities	$790,000	$96,000	$886,000
15 Floodway Control and Diversion Structures	$10,701,000	$2,043,000	$14,093,000
30 PED	$1,149,000	$81,000	$1,230,000
31 Construction Management	$919,000	$46,000	$965,000
TOTAL	**$13,654,000**	**$2,299,000**	**$15,953,000**

COST ANNEX

MII ESTIMATE

Calcasieu Lock Feasibility TSP

Estimated by	Eric Salamone
Designed by	
Prepared by	Miguel Ramos
Preparation Date	2/5/2014
Effective Date of Pricing	2/5/2014
Estimated Construction Time	Days

Description	Quantity	UOM	ContractCost	Contingency	Escalation	ProjectCost
bid schedule summary			**11,585,693.95**	**0.00**	**0.00**	**11,585,693.95**
			11,585,693.95			*11,585,693.95*
DS1 Drainage Structure	**1.0000**	**EA**	**11,585,693.95**	**0.00**	**0.00**	**11,585,693.95**
			94,500.00			*94,500.00*
01 LANDS AND DAMAGES	**1.0000**	**EA**	**94,500.00**	**0.00**	**0.00**	**94,500.00**
ACQUISITIONS	**1.0000**	**LS**	**46,500.00**	**0.00**	**0.00**	**46,500.00**
CONDEMNATIONS	**1.0000**	**LS**	**10,000.00**	**0.00**	**0.00**	**10,000.00**
APPRAISAL	**1.0000**	**LS**	**15,000.00**	**0.00**	**0.00**	**15,000.00**
REAL ESTATE PAYMENTS LAND PAYMENTS	**1.0000**	**LS**	**23,000.00**	**0.00**	**0.00**	**23,000.00**
			789,825.00			*789,825.00*
06 FISH AND WILDLIFE FACILITIES	**1.0000**	**EA**	**789,825.00**	**0.00**	**0.00**	**789,825.00**
			789,825.00			*789,825.00*
06 01 Mitigation	**1.0000**	**EA**	**789,825.00**	**0.00**	**0.00**	**789,825.00**
			10,701,368.95			*10,701,368.95*
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	**1.0000**	**EA**	**10,701,368.95**	**0.00**	**0.00**	**10,701,368.95**
15 00 01 Mob & Demob	**1.0000**	**LS**	**1,564,488.34**	**0.00**	**0.00**	**1,564,488.34**
			925,791.06			*925,791.06*
Dredging Portion	**1.0000**	**EA**	**925,791.06**	**0.00**	**0.00**	**925,791.06**
06 03 73 01 02 Mobilization and Demobilization	**1.0000**	**LS**	**925,791.06**	**0.00**	**0.00**	**925,791.06**
			36,042.94			*36,042.94*
06 03 73 01 01 Mobilization and Demobilization of dredge pipeline	**7.8000**	**DAY**	**281,134.91**	**0.00**	**0.00**	**281,134.91**
			6,846.91			*6,846.91*
Demob pickup submerged pipeline	**1.0000**	**EA**	**6,846.91**	**0.00**	**0.00**	**6,846.91**
			26,558.79			*26,558.79*
Demob pickup shore pipeline	**1.0000**	**EA**	**26,558.79**	**0.00**	**0.00**	**26,558.79**
			27,387.65			*27,387.65*
Mob prelay submerged pipeline	**1.0000**	**EA**	**27,387.65**	**0.00**	**0.00**	**27,387.65**
			26,558.79			*26,558.79*
Mob prelay shore pipeline	**1.0000**	**EA**	**26,558.79**	**0.00**	**0.00**	**26,558.79**
			45,889.68			*45,889.68*
06 03 73 01 02 Mobilization and Demobilization of pipeline crew	**1.0000**	**EA**	**45,889.68**	**0.00**	**0.00**	**45,889.68**
			23,422.40			*23,422.40*
06 03 73 01 03 Mobilization and Demobilization of Survey Crew	**1.0000**	**EA**	**23,422.40**	**0.00**	**0.00**	**23,422.40**
			5,695.41			*5,695.41*
06 03 73 01 04 Mobilization and Demobilization of Crew Boat	**1.0000**	**EA**	**5,695.41**	**0.00**	**0.00**	**5,695.41**

Description	Quantity	UOM	ContractCost	Contingency	Escalation	ProjectCost
			55,490.00			*55,490.00*
06 03 73 01 05 Mobilization and Demobilization of Marsh Cranes for pipeline crew	**1.0000**	**EA**	**55,490.00**	**0.00**	**0.00**	**55,490.00**
			9,735.09			*9,735.09*
06 03 73 01 06 Trailering Land Based Equipment	**1.0000**	**EA**	**9,735.09**	**0.00**	**0.00**	**9,735.09**
15 00 03 Care and Diversion of Water	**1.0000**	**LS**	**1,386,587.18**	**0.00**	**0.00**	**1,386,587.18**
			762,046.65			*762,046.65*
15 00 03 02 Site Work	**1.0000**	**EA**	**762,046.65**	**0.00**	**0.00**	**762,046.65**
			28.91			*28.91*
15 00 03 01 Cofferdam Sheet Piling PZ-27	**24,660.0000**	**SF**	**712,809.99**	**0.00**	**0.00**	**712,809.99**
			2.00			*2.00*
15 00 03 02 Cofferdam Removal PZ-27	**24,660.0000**	**SF**	**49,236.66**	**0.00**	**0.00**	**49,236.66**
15 00 03 15 Mechanical (Dewatering System)	**1.0000**	**LS**	**624,540.53**	**0.00**	**0.00**	**624,540.53**
			255,425.28			*255,425.28*
15 00 10 Earthwork for Structures	**1.0000**	**EA**	**255,425.28**	**0.00**	**0.00**	**255,425.28**
			51.34			*51.34*
15 00 10 01 Embankment	**4,100.0000**	**CY**	**210,513.08**	**0.00**	**0.00**	**210,513.08**
			0.64			*0.64*
1 borrow pit management	**5,125.0000**	**BCY**	**3,273.32**	**0.00**	**0.00**	**3,273.32**
			2.31			*2.31*
2 excavate, stockpile and load from borrow pit	**5,125.0000**	**BCY**	**11,822.80**	**0.00**	**0.00**	**11,822.80**
			1.95			*1.95*
3 processing/moisture control	**4,100.0000**	**ECY**	**7,986.93**	**0.00**	**0.00**	**7,986.93**
			9.17			*9.17*
4 haul embankment	**6,150.0000**	**LCY**	**56,374.26**	**0.00**	**0.00**	**56,374.26**
			5.82			*5.82*
5 Spread and Compact Fill Material	**4,100.0000**	**ECY**	**23,864.86**	**0.00**	**0.00**	**23,864.86**
			0.32			*0.32*
6 testing compacted fill	**4,100.0000**	**ECY**	**1,309.33**	**0.00**	**0.00**	**1,309.33**
			25,547.89			*25,547.89*
7 truck wash rack - set up	**4.0000**	**EA**	**102,191.56**	**0.00**	**0.00**	**102,191.56**
			117.00			*117.00*
8 truck wash rack operation	**31.5385**	**HR**	**3,690.01**	**0.00**	**0.00**	**3,690.01**
			44,912.21			*44,912.21*
15 00 10 02 Site Work	**1.0000**	**EA**	**44,912.21**	**0.00**	**0.00**	**44,912.21**
			44,912.21			*44,912.21*
15 00 10 02 01 Clearing and Grubbing	**1.0000**	**ACR**	**44,912.21**	**0.00**	**0.00**	**44,912.21**

Description	Quantity	UOM	ContractCost	Contingency	Escalation	ProjectCost
			727,798.03			*727,798.03*
15 00 29 11 Foundation Work	**1.0000**	**EA**	**727,798.03**	**0.00**	**0.00**	**727,798.03**
			10.39			*10.39*
15 00 29 02 Structural Excavation Cofferdam	**27,900.0000**	**CY**	**289,964.19**	**0.00**	**0.00**	**289,964.19**
			46.58			*46.58*
15 00 29 03 Option 2: 50-ft long 12" sq concrete Piling	**9,400.0000**	**LF**	**437,833.85**	**0.00**	**0.00**	**437,833.85**
			289,503.33			*289,503.33*
15 00 12 Seepage Control	**1.0000**	**EA**	**289,503.33**	**0.00**	**0.00**	**289,503.33**
			27.06			*27.06*
15 00 12 01 30-ft long PZ-22 Steel Sheet Piling	**10,700.0000**	**SF**	**289,503.33**	**0.00**	**0.00**	**289,503.33**
15 00 25 Embedded Metal Work	**1.0000**	**LS**	**983,043.52**	**0.00**	**0.00**	**983,043.52**
			56.64			*56.64*
15 00 25 01 Hand Rail	**250.0000**	**LF**	**14,158.96**	**0.00**	**0.00**	**14,158.96**
			6.99			*6.99*
15 00 25 02 Embedded Metals	**47,800.0000**	**LB**	**334,321.82**	**0.00**	**0.00**	**334,321.82**
			27,840.46			*27,840.46*
15 00 25 03 Trash Screens	**14.0000**	**EA**	**389,766.44**	**0.00**	**0.00**	**389,766.44**
			6.99			*6.99*
15 00 25 04 Emergency Bulkheads	**31,500.0000**	**LB**	**220,316.68**	**0.00**	**0.00**	**220,316.68**
			6.99			*6.99*
15 00 25 05 Gate Hoist Support Beam	**3,500.0000**	**LB**	**24,479.63**	**0.00**	**0.00**	**24,479.63**
			1,393,599.59			*1,393,599.59*
15 00 41 Gates, Stop Logs and Associated Equipment	**1.0000**	**EA**	**1,393,599.59**	**0.00**	**0.00**	**1,393,599.59**
			199,085.66			*199,085.66*
15 00 41 01 14'X9' Stainless Steel Slide Gates	**7.0000**	**EA**	**1,393,599.59**	**0.00**	**0.00**	**1,393,599.59**
			1,911,271.03			*1,911,271.03*
15 00 54 Stilling Basin	**1.0000**	**EA**	**1,911,271.03**	**0.00**	**0.00**	**1,911,271.03**
			1,911,271.03			*1,911,271.03*
15 00 54 13 Special Construction	**1.0000**	**EA**	**1,911,271.03**	**0.00**	**0.00**	**1,911,271.03**
15 00 54 13 01 Channel Excavation	**1.0000**	**LS**	**1,511,570.28**	**0.00**	**0.00**	**1,511,570.28**
			3.98			*3.98*
06 03 73 01 02 Inflow Channel Dredging	**70,000.0000**	**CY**	**278,462.44**	**0.00**	**0.00**	**278,462.44**
			3.78			*3.78*
06 03 73 01 03 Outflow Channel Dredging	**145,000.0000**	**CY**	**548,731.17**	**0.00**	**0.00**	**548,731.17**
			46.24			*46.24*
06 03 73 01 05 Earthen Closure (5.5 cy/lf)	**7,300.0000**	**LF**	**337,564.17**	**0.00**	**0.00**	**337,564.17**

Description	Quantity	UOM	ContractCost	Contingency	Escalation	ProjectCost
			21.02			*21.02*
06 03 73 01 06 Earthen Weir (2.5 cy/lf)	**16,500.0000**	**LF**	**346,812.50**	**0.00**	**0.00**	**346,812.50**
			41.58			*41.58*
15 00 54 13 02 36" Riprap (Wet)	**6,380.0000**	**TON**	**265,267.52**	**0.00**	**0.00**	**265,267.52**
			43.65			*43.65*
15 00 54 13 03 24" Riprap (Dry)	**2,280.0000**	**TON**	**99,527.78**	**0.00**	**0.00**	**99,527.78**
			5.09			*5.09*
15 00 54 13 04 Separator Geotextile	**6,860.0000**	**SY**	**34,905.45**	**0.00**	**0.00**	**34,905.45**
15 00 53 Overflow Structure	**1.0000**	**LS**	**1,005,411.52**	**0.00**	**0.00**	**1,005,411.52**
			1,005,411.52			*1,005,411.52*
15 00 53 03 Concrete	**1.0000**	**EA**	**1,005,411.52**	**0.00**	**0.00**	**1,005,411.52**
			309.64			*309.64*
15 00 53 01 Reinforced Slabs	**1,260.0000**	**CY**	**390,151.88**	**0.00**	**0.00**	**390,151.88**
			586.76			*586.76*
15 00 53 02 Reinforce Walls	**650.0000**	**CY**	**381,395.13**	**0.00**	**0.00**	**381,395.13**
			443.16			*443.16*
15 00 53 03 Reinforced Roof	**431.0000**	**CY**	**191,000.34**	**0.00**	**0.00**	**191,000.34**
15 00 53 04 Unreinforced Concrete	**1.0000**	**LS**	**42,864.16**	**0.00**	**0.00**	**42,864.16**
			252.14			*252.14*
03 Stabilization Slab	**170.0000**	**CY**	**42,864.16**	**0.00**	**0.00**	**42,864.16**
			1,184,241.12			*1,184,241.12*
15 00 99 Associated General Items	**1.0000**	**EA**	**1,184,241.12**	**0.00**	**0.00**	**1,184,241.12**
			17,621.28			*17,621.28*
15 00 99 01 5 Timber Pile Cluster (60' long)	**14.0000**	**EA**	**246,697.88**	**0.00**	**0.00**	**246,697.88**
			924,806.58			*924,806.58*
15 00 99 02 Electrical	**1.0000**	**EA**	**924,806.58**	**0.00**	**0.00**	**924,806.58**
12 Power and Lighting	**1.0000**	**LS**	**192,463.42**	**0.00**	**0.00**	**192,463.42**
			19,010.13			*19,010.13*
Cameras	**8.0000**	**EA**	**152,081.08**	**0.00**	**0.00**	**152,081.08**
0001 Electrical Distribution Equipment	**1.0000**	**LS**	**2,189.51**	**0.00**	**0.00**	**2,189.51**
0002 Ethernet Equipment and CCTV Cameras	**1.0000**	**LS**	**93,591.92**	**0.00**	**0.00**	**93,591.92**
0003 Control and CCTV Equipment Accessories	**1.0000**	**LS**	**14,411.72**	**0.00**	**0.00**	**14,411.72**
0004 Conductors and Cables	**1.0000**	**LS**	**4,563.59**	**0.00**	**0.00**	**4,563.59**
0005 Boxes and Raceway	**1.0000**	**LS**	**35,213.26**	**0.00**	**0.00**	**35,213.26**
0006 Light Fixtures	**1.0000**	**LS**	**2,111.07**	**0.00**	**0.00**	**2,111.07**

Description	Quantity	UOM	ContractCost	Contingency	Escalation	ProjectCost
Hard Wired and PLC Control System	**1.0000**	**LS**	**580,262.08**	**0.00**	**0.00**	**580,262.08**
			12,736.66			*12,736.66*
15 00 99 03 Access Road	**1.0000**	**EA**	**12,736.66**	**0.00**	**0.00**	**12,736.66**
			45.29			*45.29*
15 00 29 04 01 Bedding	**230.0000**	**TON**	**10,416.41**	**0.00**	**0.00**	**10,416.41**
			5.09			*5.09*
15 00 29 04 01 Separator Geotextile	**456.0000**	**SY**	**2,320.25**	**0.00**	**0.00**	**2,320.25**

Description	UOM	Quantity	DirectCost	CostToPrime	ContractCost	ProjectCost
summary			**8,769,492.51**	**8,377,496.93**	**11,585,693.95**	**11,585,693.95**
			8,769,492.5075	*8,377,496.9321*	*11,585,693.9495*	*11,585,693.9495*
DS1 Drainage Structure	**EA**	**1.0000**	**8,769,492.51**	**8,377,496.93**	**11,585,693.95**	**11,585,693.95**
			94,500.0000	*0.0000*	*94,500.0000*	*94,500.0000*
01 LANDS AND DAMAGES	**EA**	**1.0000**	**94,500.00**	**0.00**	**94,500.00**	**94,500.00**
ACQUISITIONS	**LS**	**1.0000**	**46,500.00**	**0.00**	**46,500.00**	**46,500.00**
CONDEMNATIONS	**LS**	**1.0000**	**10,000.00**	**0.00**	**10,000.00**	**10,000.00**
APPRAISAL	**LS**	**1.0000**	**15,000.00**	**0.00**	**15,000.00**	**15,000.00**
REAL ESTATE PAYMENTS LAND PAYMENTS	**LS**	**1.0000**	**23,000.00**	**0.00**	**23,000.00**	**23,000.00**
			789,825.0000	*0.0000*	*789,825.0000*	*789,825.0000*
06 FISH AND WILDLIFE FACILITIES	**EA**	**1.0000**	**789,825.00**	**0.00**	**789,825.00**	**789,825.00**
			789,825.0000	*0.0000*	*789,825.0000*	*789,825.0000*
06 01 Mitigation	**EA**	**1.0000**	**789,825.00**	**0.00**	**789,825.00**	**789,825.00**
			7,885,167.5075	*8,377,496.9321*	*10,701,368.9495*	*10,701,368.9495*
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	**EA**	**1.0000**	**7,885,167.51**	**8,377,496.93**	**10,701,368.95**	**10,701,368.95**
15 00 01 Mob & Demob	**LS**	**1.0000**	**1,070,590.27**	**1,224,749.50**	**1,564,488.34**	**1,564,488.34**
			570,590.2723	*724,749.4991*	*925,791.0625*	*925,791.0625*
Dredging Portion	**EA**	**1.0000**	**570,590.27**	**724,749.50**	**925,791.06**	**925,791.06**
06 03 73 01 02 Mobilization and Demobilization	**LS**	**1.0000**	**570,590.27**	**724,749.50**	**925,791.06**	**925,791.06**
			22,214.2450	*28,215.9787*	*36,042.9375*	*36,042.9375*
06 03 73 01 01 Mobilization and Demobilization of dredge pipeline	**DAY**	**7.8000**	**173,271.11**	**220,084.63**	**281,134.91**	**281,134.91**
			4,219.9390	*5,360.0610*	*6,846.9127*	*6,846.9127*
Demob pickup submerged pipeline	**EA**	**1.0000**	**4,219.94**	**5,360.06**	**6,846.91**	**6,846.91**
			16,368.9082	*20,791.3780*	*26,558.7930*	*26,558.7930*
Demob pickup shore pipeline	**EA**	**1.0000**	**16,368.91**	**20,791.38**	**26,558.79**	**26,558.79**
			16,879.7559	*21,440.2440*	*27,387.6508*	*27,387.6508*
Mob prelay submerged pipeline	**EA**	**1.0000**	**16,879.76**	**21,440.24**	**27,387.65**	**27,387.65**
			16,368.9082	*20,791.3780*	*26,558.7930*	*26,558.7930*
Mob prelay shore pipeline	**EA**	**1.0000**	**16,368.91**	**20,791.38**	**26,558.79**	**26,558.79**
			28,283.0619	*35,924.4381*	*45,889.6815*	*45,889.6815*
06 03 73 01 02 Mobilization and Demobilization of pipeline crew	**EA**	**1.0000**	**28,283.06**	**35,924.44**	**45,889.68**	**45,889.68**
			14,435.8645	*18,336.0742*	*23,422.4013*	*23,422.4013*
06 03 73 01 03 Mobilization and Demobilization of Survey Crew	**EA**	**1.0000**	**14,435.86**	**18,336.07**	**23,422.40**	**23,422.40**
			3,510.2346	*4,458.6122*	*5,695.4070*	*5,695.4070*
06 03 73 01 04 Mobilization and Demobilization of Crew Boat	**EA**	**1.0000**	**3,510.23**	**4,458.61**	**5,695.41**	**5,695.41**

Description	UOM	Quantity	DirectCost	CostToPrime	ContractCost	ProjectCost
			34,200.0000	*43,439.9850*	*55,490.0002*	*55,490.0002*
06 03 73 01 05 Mobilization and Demobilization of Marsh Cranes for pipeline crew	**EA**	**1.0000**	**34,200.00**	**43,439.99**	**55,490.00**	**55,490.00**
			6,000.0000	*7,621.0500*	*9,735.0878*	*9,735.0878*
06 03 73 01 06 Trailering Land Based Equipment	**EA**	**1.0000**	**6,000.00**	**7,621.05**	**9,735.09**	**9,735.09**
15 00 03 Care and Diversion of Water	**LS**	**1.0000**	**1,085,480.74**	**1,085,480.74**	**1,386,587.18**	**1,386,587.18**
			596,563.2547	*596,563.2547*	*762,046.6521*	*762,046.6521*
15 00 03 02 Site Work	**EA**	**1.0000**	**596,563.25**	**596,563.25**	**762,046.65**	**762,046.65**
			22.6285	*22.6285*	*28.9055*	*28.9055*
15 00 03 01 Cofferdam Sheet Piling PZ-27	**SF**	**24,660.0000**	**558,018.66**	**558,018.66**	**712,809.99**	**712,809.99**
			1.5630	*1.5630*	*1.9966*	*1.9966*
15 00 03 02 Cofferdam Removal PZ-27	**SF**	**24,660.0000**	**38,544.60**	**38,544.60**	**49,236.66**	**49,236.66**
15 00 03 15 Mechanical (Dewatering System)	**LS**	**1.0000**	**488,917.48**	**488,917.48**	**624,540.53**	**624,540.53**
			199,958.0195	*199,958.0195*	*255,425.2850*	*255,425.2850*
15 00 10 Earthwork for Structures	**EA**	**1.0000**	**199,958.02**	**199,958.02**	**255,425.28**	**255,425.28**
			40.1948	*40.1948*	*51.3447*	*51.3447*
15 00 10 01 Embankment	**CY**	**4,100.0000**	**164,798.79**	**164,798.79**	**210,513.08**	**210,513.08**
			0.5000	*0.5000*	*0.6387*	*0.6387*
1 borrow pit management	**BCY**	**5,125.0000**	**2,562.50**	**2,562.50**	**3,273.32**	**3,273.32**
			1.8059	*1.8059*	*2.3069*	*2.3069*
2 excavate, stockpile and load from borrow pit	**BCY**	**5,125.0000**	**9,255.40**	**9,255.40**	**11,822.80**	**11,822.80**
			1.5250	*1.5250*	*1.9480*	*1.9480*
3 processing/moisture control	**ECY**	**4,100.0000**	**6,252.52**	**6,252.52**	**7,986.93**	**7,986.93**
			7.1760	*7.1760*	*9.1665*	*9.1665*
4 haul embankment	**LCY**	**6,150.0000**	**44,132.22**	**44,132.22**	**56,374.26**	**56,374.26**
			4.5567	*4.5567*	*5.8207*	*5.8207*
5 Spread and Compact Fill Material	**ECY**	**4,100.0000**	**18,682.45**	**18,682.45**	**23,864.86**	**23,864.86**
			0.2500	*0.2500*	*0.3193*	*0.3193*
6 testing compacted fill	**ECY**	**4,100.0000**	**1,025.00**	**1,025.00**	**1,309.33**	**1,309.33**
			20,000.0000	*20,000.0000*	*25,547.8911*	*25,547.8911*
7 truck wash rack - set up	**EA**	**4.0000**	**80,000.00**	**80,000.00**	**102,191.56**	**102,191.56**
			91.5930	*91.5930*	*117.0004*	*117.0004*
8 truck wash rack operation	**HR**	**31.5385**	**2,888.70**	**2,888.70**	**3,690.01**	**3,690.01**
			35,159.2276	*35,159.2276*	*44,912.2058*	*44,912.2058*
15 00 10 02 Site Work	**EA**	**1.0000**	**35,159.23**	**35,159.23**	**44,912.21**	**44,912.21**

Description	UOM	Quantity	DirectCost	CostToPrime	ContractCost	ProjectCost
			35,159.2276	*35,159.2276*	*44,912.2058*	*44,912.2058*
15 00 10 02 01 Clearing and Grubbing	**ACR**	**1.0000**	**35,159.23**	**35,159.23**	**44,912.21**	**44,912.21**
			569,751.9471	*569,751.9471*	*727,798.0338*	*727,798.0338*
15 00 29 11 Foundation Work	**EA**	**1.0000**	**569,751.95**	**569,751.95**	**727,798.03**	**727,798.03**
			8.1361	*8.1361*	*10.3930*	*10.3930*
15 00 29 02 Structural Excavation Cofferdam	**CY**	**27,900.0000**	**226,996.58**	**226,996.58**	**289,964.19**	**289,964.19**
			36.4633	*36.4633*	*46.5781*	*46.5781*
15 00 29 03 Option 2: 50-ft long 12" sq concrete Piling	**LF**	**9,400.0000**	**342,755.37**	**342,755.37**	**437,833.85**	**437,833.85**
			226,635.7943	*226,635.7943*	*289,503.3292*	*289,503.3292*
15 00 12 Seepage Control	**EA**	**1.0000**	**226,635.79**	**226,635.79**	**289,503.33**	**289,503.33**
			21.1809	*21.1809*	*27.0564*	*27.0564*
15 00 12 01 30-ft long PZ-22 Steel Sheet Piling	**SF**	**10,700.0000**	**226,635.79**	**226,635.79**	**289,503.33**	**289,503.33**
15 00 25 Embedded Metal Work	**LS**	**1.0000**	**769,569.21**	**769,569.21**	**983,043.52**	**983,043.52**
			44.3370	*44.3370*	*56.6358*	*56.6358*
15 00 25 01 Hand Rail	**LF**	**250.0000**	**11,084.25**	**11,084.25**	**14,158.96**	**14,158.96**
			5.4753	*5.4753*	*6.9942*	*6.9942*
15 00 25 02 Embedded Metals	**LB**	**47,800.0000**	**261,721.65**	**261,721.65**	**334,321.82**	**334,321.82**
			21,794.7225	*21,794.7225*	*27,840.4598*	*27,840.4598*
15 00 25 03 Trash Screens	**EA**	**14.0000**	**305,126.12**	**305,126.12**	**389,766.44**	**389,766.44**
			5.4753	*5.4753*	*6.9942*	*6.9942*
15 00 25 04 Emergency Bulkheads	**LB**	**31,500.0000**	**172,473.48**	**172,473.48**	**220,316.68**	**220,316.68**
			5.4753	*5.4753*	*6.9942*	*6.9942*
15 00 25 05 Gate Hoist Support Beam	**LB**	**3,500.0000**	**19,163.72**	**19,163.72**	**24,479.63**	**24,479.63**
			1,090,970.3570	*1,090,970.3570*	*1,393,599.5916*	*1,393,599.5916*
15 00 41 Gates, Stop Logs and Associated Equipment	**EA**	**1.0000**	**1,090,970.36**	**1,090,970.36**	**1,393,599.59**	**1,393,599.59**
			155,852.9081	*155,852.9081*	*199,085.6559*	*199,085.6559*
15 00 41 01 14'X9' Stainless Steel Slide Gates	**EA**	**7.0000**	**1,090,970.36**	**1,090,970.36**	**1,393,599.59**	**1,393,599.59**
			1,244,525.1049	*1,496,226.0713*	*1,911,271.0337*	*1,911,271.0337*
15 00 54 Stilling Basin	**EA**	**1.0000**	**1,244,525.10**	**1,496,226.07**	**1,911,271.03**	**1,911,271.03**
			1,244,525.1049	*1,496,226.0713*	*1,911,271.0337*	*1,911,271.0337*
15 00 54 13 Special Construction	**EA**	**1.0000**	**1,244,525.10**	**1,496,226.07**	**1,911,271.03**	**1,911,271.03**
15 00 54 13 01 Channel Excavation	**LS**	**1.0000**	**931,621.97**	**1,183,322.94**	**1,511,570.28**	**1,511,570.28**
			2.4518	*3.1142*	*3.9780*	*3.9780*
06 03 73 01 02 Inflow Channel Dredging	**CY**	**70,000.0000**	**171,623.99**	**217,992.50**	**278,462.44**	**278,462.44**
			2.3324	*2.9626*	*3.7844*	*3.7844*
06 03 73 01 03 Outflow Channel Dredging	**CY**	**145,000.0000**	**338,197.98**	**429,570.62**	**548,731.17**	**548,731.17**

Description	UOM	Quantity	DirectCost	CostToPrime	ContractCost	ProjectCost
			28.5000	*36.2000*	*46.2417*	*46.2417*
06 03 73 01 05 Earthen Closure (5.5 cy/lf)	**LF**	**7,300.0000**	**208,050.00**	**264,259.91**	**337,564.17**	**337,564.17**
			12.9545	*16.4545*	*21.0189*	*21.0189*
06 03 73 01 06 Earthen Weir (2.5 cy/lf)	**LF**	**16,500.0000**	**213,750.00**	**271,499.91**	**346,812.50**	**346,812.50**
			32.5491	*32.5491*	*41.5780*	*41.5780*
15 00 54 13 02 36" Riprap (Wet)	**TON**	**6,380.0000**	**207,662.95**	**207,662.95**	**265,267.52**	**265,267.52**
			34.1731	*34.1731*	*43.6525*	*43.6525*
15 00 54 13 03 24" Riprap (Dry)	**TON**	**2,280.0000**	**77,914.68**	**77,914.68**	**99,527.78**	**99,527.78**
			3.9833	*3.9833*	*5.0883*	*5.0883*
15 00 54 13 04 Separator Geotextile	**SY**	**6,860.0000**	**27,325.50**	**27,325.50**	**34,905.45**	**34,905.45**
15 00 53 Overflow Structure	**LS**	**1.0000**	**787,079.85**	**787,079.85**	**1,005,411.52**	**1,005,411.52**
			787,079.8535	*787,079.8535*	*1,005,411.5177*	*1,005,411.5177*
15 00 53 03 Concrete	**EA**	**1.0000**	**787,079.85**	**787,079.85**	**1,005,411.52**	**1,005,411.52**
			242.4031	*242.4031*	*309.6444*	*309.6444*
15 00 53 01 Reinforced Slabs	**CY**	**1,260.0000**	**305,427.86**	**305,427.86**	**390,151.88**	**390,151.88**
			459.3426	*459.3426*	*586.7617*	*586.7617*
15 00 53 02 Reinforce Walls	**CY**	**650.0000**	**298,572.69**	**298,572.69**	**381,395.13**	**381,395.13**
			346.9220	*346.9220*	*443.1562*	*443.1562*
15 00 53 03 Reinforced Roof	**CY**	**431.0000**	**149,523.37**	**149,523.37**	**191,000.34**	**191,000.34**
15 00 53 04 Unreinforced Concrete	**LS**	**1.0000**	**33,555.93**	**33,555.93**	**42,864.16**	**42,864.16**
			197.3878	*197.3878*	*252.1421*	*252.1421*
03 Stabilization Slab	**CY**	**170.0000**	**33,555.93**	**33,555.93**	**42,864.16**	**42,864.16**
			840,606.2092	*927,075.4406*	*1,184,241.1181*	*1,184,241.1181*
15 00 99 Associated General Items	**EA**	**1.0000**	**840,606.21**	**927,075.44**	**1,184,241.12**	**1,184,241.12**
			13,794.7019	*13,794.7019*	*17,621.2770*	*17,621.2770*
15 00 99 01 5 Timber Pile Cluster (60' long)	**EA**	**14.0000**	**193,125.83**	**193,125.83**	**246,697.88**	**246,697.88**
			637,509.5731	*723,978.8045*	*924,806.5814*	*924,806.5814*
15 00 99 02 Electrical	**EA**	**1.0000**	**637,509.57**	**723,978.80**	**924,806.58**	**924,806.58**
12 Power and Lighting	**LS**	**1.0000**	**132,673.44**	**150,668.74**	**192,463.42**	**192,463.42**
			13,104.5162	*14,881.9600*	*19,010.1346*	*19,010.1346*
Cameras	**EA**	**8.0000**	**104,836.13**	**119,055.68**	**152,081.08**	**152,081.08**
0001 Electrical Distribution Equipment	**LS**	**1.0000**	**1,509.33**	**1,714.05**	**2,189.51**	**2,189.51**
0002 Ethernet Equipment and CCTV Cameras	**LS**	**1.0000**	**64,517.00**	**73,267.83**	**93,591.92**	**93,591.92**
0003 Control and CCTV Equipment Accessories	**LS**	**1.0000**	**9,934.63**	**11,282.12**	**14,411.72**	**14,411.72**
0004 Conductors and Cables	**LS**	**1.0000**	**3,145.88**	**3,572.58**	**4,563.59**	**4,563.59**

Description	UOM	Quantity	DirectCost	CostToPrime	ContractCost	ProjectCost
0005 Boxes and Raceway	**LS**	**1.0000**	**24,274.04**	**27,566.47**	**35,213.26**	**35,213.26**
0006 Light Fixtures	**LS**	**1.0000**	**1,455.25**	**1,652.64**	**2,111.07**	**2,111.07**
Hard Wired and PLC Control System	**LS**	**1.0000**	**400,000.00**	**454,254.39**	**580,262.08**	**580,262.08**
			9,970.8098	*9,970.8098*	*12,736.6582*	*12,736.6582*
15 00 99 03 Access Road	**EA**	**1.0000**	**9,970.81**	**9,970.81**	**12,736.66**	**12,736.66**
			35.4540	*35.4540*	*45.2888*	*45.2888*
15 00 29 04 01 Bedding	**TON**	**230.0000**	**8,154.42**	**8,154.42**	**10,416.41**	**10,416.41**
			3.9833	*3.9833*	*5.0883*	*5.0883*
15 00 29 04 01 Separator Geotextile	**SY**	**456.0000**	**1,816.39**	**1,816.39**	**2,320.25**	**2,320.25**

Description	Page

Description	Page

ABBREVIATED CRA

Abbreviated Risk Analysis

Calcasieu Lock TSP
Feasibility (Recommended Plan)

Meeting Date: 20-Feb-14

PDT Members

Note: PDT involvement is commensurate with project size and involvement.

Project Management:	Jeffery Varisco
Planner:	Marshall Plumley
Study Manager:	Jeffrey Varisco
Contracting:	N/A
Real Estate:	Karen Vance
Relocations:	NAME
OTHER:	NAME
Engineering & Design:	Pam Deloach
Technical Lead:	Craig Waugeman
Geotech:	Thomas West//Bruce Bivona
Hydrology:	Paul Bellocq
Civil:	Brian Leaumont
Structural:	Craig Waugeman
Mechanical:	Rachel Maltsahn
Electrical:	Jabeen Pasha
Cost Engineering:	Eric Salamone//Miguel Ramos
Construction:	NAME
Operations:	Doyle Hunt
OTHER:	NAME
OTHER:	NAME
OTHER:	NAME
OTHER:	NAME
OTHER:	NAME
OTHER:	NAME
OTHER:	NAME
OTHER:	NAME

Terminology

Term	**Definition**
Risk Analysis ER 1110-2-1302, 15 Sep 08, page 19	a. Cost risk analysis is the process of identifying and measuring the cost impact of project uncertainties on the estimated TPC. It shall be accomplished as a joint analysis between the cost engineer and the designers or appropriate PDT members that have specific knowledge and expertise on all possible project risks. (1) PDTs are required to prepare a formal cost risk analysis for all decision documents requiring Congressional authorization for projects exceeding $40 million (TPC)(see appendix B). Where cost risk analysis is required, it is anticipated that the cost risk analysis will be performed once the recommended plan is identified prior to the alternative formulation briefing milestone.
Typical Risk Elements	Factors that can introduce risk to items listed in the Selected Work Breakdown Structure Items. The ones listed are the most typical for Civil Works Projects. These Risk Elements should be reviewed and established for each project.
Potential Risk Areas	These are items from the estimate's Work Breakdown Structure, either broad or detailed, that are believed to contain some risk. The cost estimator defines the Work Breakdown Structure. It is recommended that the PDT select the appropriate Selected Work Breakdown Structure Items and considers all Features. Focus should be placed on the items with the significant risks. Appropriately identifying the Selected Work Breakdown Structure Items will lead to a more confident development of contingency.

Typical Risk Elements

Risk Element	**Typical Concerns**
Project Scope Growth	• Potential for scope growth, added features and quantities? • Project accomplish intent? • Investigations sufficient to support design assumptions? • Design confidence? • Water care and diversion fully understood, planned?
Acquisition Strategy	• Contracting plan firmly established? • 8a or small business likely? • Requirement for subcontracting? • Accelerated schedule or harsh weather schedule? • High-risk acquisition limits competition, design/build? • Limited bid competition anticipated? • Bid schedule developed to reduce quantity risks?
Construction Elements	• Accelerated schedule or harsh weather schedule? • High risk or complex construction elements, site access, in-water? • Water care and diversion plan? • Unique construction methods? • Special mobilization? • Special equipment or subcontractors needed? • Potential for construction modification and claims?
Quantities for Current Scope	• Level of confidence based on design and assumptions? • Possibility for increased quantities due to loss, waste, or subsidence? • Appropriate methods applied to calculate quantities? • Sufficient investigations to develop quantities? • Quality control check applied?
Specialty Fabrication or Equipment	• Unusual parts, material or equipment manufactured or installed? • Confidence in suppliers' ability? • Confidence in contractor's ability to install? • Ability to reasonably transport? • Risk of specialty equipment functioning first time? Test?
Cost Estimate Assumptions	• Reliability and number of key quotes? • Assumptions related to prime and subcontractor markups/assignments? • Assumptions regarding crew, productivity, overtime? • Site accessibility, transport delays, congestion? • Overuse of Cost Book, lump sum, allowances? • Lack confidence on critical cost items?
External Project Risks	• Potential for severe adverse weather? • Political influences, lack of support, obstacles? • Unanticipated inflations in fuel, key materials? • Potential for market volatility impacting competition, pricing?

Abbreviated Risk Analysis

Project (less than $40M): **Calcasieu Lock TSP**
Project Development Stage: **Feasibility (Recommended Plan)**
Risk Category: **Low Risk: Simple Project-No Life Safety**

Total Construction Contract Cost = **$ 10,701,369**

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ 94,500		34.80%	$ 32,886	$ 127,386.00
1	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Mobilization - Demobilization	$ 1,564,488		8.90%	$ 139,209	$ 1,703,697.45
2	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Care and Diversion of Water	$ 1,386,587		26.96%	$ 373,868	$ 1,760,455.28
3	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Earthwork for Structures	$ 255,425		14.30%	$ 36,536	$ 291,960.78
4	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Foundation Work	$ 727,798		24.78%	$ 180,323	$ 908,120.64
5	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Seepage Control	$ 289,503		24.78%	$ 71,729	$ 361,232.02
6	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Embedded Metal Work	$ 983,044		23.06%	$ 226,667	$ 1,209,710.66
7	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Gates, Stop Logs and Associated Eq	$ 1,393,600		21.81%	$ 303,878	$ 1,697,477.85
8	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Channel Excavation	$ 1,511,570		18.84%	$ 284,842	$ 1,796,411.79
9	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Concrete	$ 1,005,412		18.84%	$ 189,461	$ 1,194,872.07
12		Remaining Construction Items	$ 1,583,942	*17.4%*	14.93%	$ 236,518	$ 1,820,459.82
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	$ 93,000		7.09%	$ 6,595	$ 99,594.89
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 61,380		5.00%	$ 3,069	$ 64,449.00

Totals	Contract Cost	% Contingency	$ Contingency	Total
Real Estate	$ 94,500	34.80%	$ 32,886	$ 127,386.00
Total Construction Estimate	$ 10,701,369	19.09%	$ 2,043,029	$ 12,744,398
Total Planning, Engineering & Design	$ 93,000	7.09%	$ 6,595	$ 99,595
Total Construction Management	$ 61,380	5.00%	$ 3,069	$ 64,449
Total	$ 10,950,249		$ 2,085,579	$ 13,035,828

Calcasieu Lock TSP
Feasibility (Recommended Plan)
Abbreviated Risk Analysis

Meeting Date: 20-Feb-14

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Project Scope Growth							
						Max Potential Cost Growth	40%
PS-1	Mobilization - Demobilization	• Design confidence?	• Design confidence?	From planning perspective, common work for the MVN district, no new items of work would be added to the scope and therefore no new mob/demob anticpated. PDT recommends unlikely/negligible.	Unlikely	Marginal	0
PS-2	Care and Diversion of Water	• Investigations sufficient to support design assumptions?	• Investigations sufficient to support design assumptions?	There is a potential that the channel alignment or structure location could shift due to unforseen circumstances that might impact navigation. The result would require more environmental work with state and agencies. PDT believes this is an unlikely scenario, but the impact to cost/schedule is significant.	Unlikely	Significant	1
PS-3	Earthwork for Structures	• Investigations sufficient to support design assumptions?	• Investigations sufficient to support design assumptions?	There is a potential that the channel alignment or structure location could shift due to unforseen circumstances that might impact navigation. The result would require more environmental work with state and agencies. PDT believes this is an unlikely scenario, but the impact to cost/schedule is significant.	Unlikely	Significant	1
PS-4	Foundation Work	• Investigations sufficient to support design assumptions?	• Investigations sufficient to support design assumptions?	There is a potential that the channel alignment or structure location could shift due to unforseen circumstances that might impact navigation. The result would require more environmental work with state and agencies. PDT believes this is an unlikely scenario, but the impact to cost/schedule is significant.	Unlikely	Significant	1
PS-5	Seepage Control	• Investigations sufficient to support design assumptions?	• Investigations sufficient to support design assumptions?	There is a potential that the channel alignment or structure location could shift due to unforseen circumstances that might impact navigation. The result would require more environmental work with state and agencies. PDT believes this is an unlikely scenario, but the impact to cost/schedule is significant.	Unlikely	Significant	1
PS-6	Embedded Metal Work	• Investigations sufficient to support design assumptions?	• Investigations sufficient to support design assumptions?	There is a potential that the channel alignment or structure location could shift due to unforseen circumstances that might impact navigation. The result would require more environmental work with state and agencies. PDT believes this is an unlikely scenario, but the impact to cost/schedule is significant.	Unlikely	Significant	1
PS-7	Gates, Stop Logs and Associated Eq	• Investigations sufficient to support design assumptions?	• Investigations sufficient to support design assumptions?	There is a potential that the channel alignment or structure location could shift due to unforseen circumstances that might impact navigation. The result would require more environmental work with state and agencies. PDT believes this is an unlikely scenario, but the impact to cost/schedule is significant.	Unlikely	Significant	1
PS-8	Channel Excavation	• Investigations sufficient to support design assumptions?	• Potential for scope growth, added features and quantities? • Investigations sufficient to support design assumptions?	There is a potential that the channel alignment or structure location could shift due to unforseen circumstances that might impact navigation. The result would require more environmental work with state and agencies. PDT believes this is an unlikely scenario, but the impact to cost/schedule is significant.	Unlikely	Significant	1
PS-9	Concrete	• Investigations sufficient to support design assumptions?	• Potential for scope growth, added features and quantities? • Investigations sufficient to support design assumptions?	There is a potential that the channel alignment or structure location could shift due to unforseen circumstances that might impact navigation. The result would require more environmental work with state and agencies. PDT believes this is an unlikely scenario, but the impact to cost/schedule is significant.	Unlikely	Significant	1

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
PS-10	0	• Investigations sufficient to support design assumptions?			Unlikely	Negligible	0
PS-11	0	• Potential for scope growth, added features and quantities?			Unlikely	Negligible	0
PS-12	Remaining Construction Items	• Potential for scope growth, added features and quantities?	• Potential for scope growth, added features and quantities?	A guidwall in lieu of protection dolphins could be required. The electrical items have a negligble chance of changing.	Unlikely	Negligible	0
PS-13	Planning, Engineering, & Design	• Investigations sufficient to support design assumptions?	• Investigations sufficient to support design assumptions?	There is a potential that the channel alignment or structure location could shift due to unforseen circumstances that might impact navigation. The result would require more environmental work with state and agencies. PDT believes this is an unlikely scenario, but the impact to cost/schedule is significant.	Unlikely	Significant	1
PS-14	Construction Management	• Investigations sufficient to support design assumptions?	• Investigations sufficient to support design assumptions?	There is a potential that the channel alignment or structure location could shift due to unforseen circumstances that might impact navigation. The result would require more environmental work with state and agencies. PDT believes this is an unlikely scenario, but the impact to cost/schedule is significant.	Unlikely	Negligible	0
Acquisition Strategy							
						Max Potential Cost Growth	30%
AS-1	Mobilization - Demobilization	• Contracting plan firmly established?	• 8a or small business likely • Contracting plan firmly established?	At feasibility level of design, contracting plan is not fully developed. Anticipated design - bid - build is expected for 1 contract. PDT feels that risk is low on a 'low-bid' contract. There are no odd or special contract acquisitions anticipated when plans and specs are put out for bid. A possibilty that contract is awarded to an 8aA.	Possible	Significant	2
AS-2	Care and Diversion of Water	• Contracting plan firmly established?	• 8a or small business likely? • Contracting plan firmly established?	At feasibility level of design, contracting plan is not fully developed. Anticipated design - bid - build is expected for 1 contractCofferdam construction is a common construction item for local contractors - detailed acquisition of materials will be developed in PED so timing could change slightly for sheet piling. A possibiity that contract is awarded to an 8A.	Possible	Significant	2
AS-3	Earthwork for Structures	• Contracting plan firmly established?	• 8a or small business likely? • Contracting plan firmly established?	At feasibility level of design, contracting plan is not fully developed. Anticipated design - bid - build is expected for 1 contract. There is a good opurtunity to obtain material within the 10 mile haul distance assumed. After borings are obtained the adjacent material may be found to be reasonable and be used as backfill. Possibility that contract awarded to an 8A.	Possible	Significant	2
AS-4	Foundation Work	• 8a or small business likely?	• Contracting plan firmly established? • 8a or small business likely?	At feasibility level of design, contracting plan is not fully developed. Anticipated design - bid - build is expected for 1 contract. Team has some concern about acquiring pilings and machinery without affecting cost. While it is unlikely, team feels the actual impact is marginal. Possibility that contract awarded to an 8A.	Possible	Significant	2
AS-5	Seepage Control	• 8a or small business likely?	At feasibility level of design, contracting plan is not fully developed. Anticipated design - bid - build is expected for 1 contract • Contracting plan firmly established? • 8a or small business likely?	At feasibility level of design, contracting plan is not fully developed. Anticipated design - bid - build is expected for 1 contract. Team has some concern about acquiring pilings and machinery without affecting cost. While it is unlikely, team feels the actual impact is marginal. Possibility that contract awarded to an 8A.	Possible	Significant	2

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
AS-6	Embedded Metal Work	• 8a or small business likely?	• Contracting plan firmly established? • 8a or small business likely?	At feasibility level of design, contracting plan is not fully developed. Anticipated design - bid - build is expected for 1 contractTeam has some concern about acquiring pilings and machinery without affecting cost. While it is unlikely, team feels the actual impact is marginal.	Possible	Significant	2
AS-7	Gates, Stop Logs and Associated Eq	• 8a or small business likely?	• Contracting plan firmly established? • 8a or small business likely?	At feasibility level of design, contracting plan is not fully developed. Anticipated design - bid - build is expected for 1 contract. Team has some concern about acquiring pilings and machinery without affecting cost. While it is unlikely, team feels the actual impact is marginal.	Possible	Significant	2
AS-8	Channel Excavation	• 8a or small business likely?	• Contracting plan firmly established? • 8a or small business likely?	At feasibility level of design, contracting plan is not fully developed. Anticipated design - bid - build is expected for 1 contract. Dredging is subcontracted in MII. Entire project could be awarded to 8A..	Possible	Significant	2
AS-9	Concrete	• 8a or small business likely?	• Contracting plan firmly established? • 8a or small business likely?	At feasibility level of design, contracting plan is not fully developed. Anticipated design - bid - build is expected for 1 contract	Possible	Significant	2
AS-10	0	• Contracting plan firmly established?			Unlikely	Negligible	0
AS-11	0	• Contracting plan firmly established?			Unlikely	Negligible	0
AS-12	Remaining Construction Items	• Contracting plan firmly established?	• 8a or small business likely? • Contracting plan firmly established?	The entire project could be awarded to an 8a. This would slightly increase cost. The electrical items are already subcontracted in the MII.	Possible	Significant	2
AS-13	Planning, Engineering, & Design	• High-risk acquisition limits competition, design/build?	• Contracting plan firmly established? • 8a or small business likely?	PDT discussed acquisition strategies however unlikely to change these cost.	Unlikely	Negligible	0
AS-14	Construction Management	• 8a or small business likely?	• Contracting plan firmly established? • 8a or small business likely?	PDT discussed acquisition strategies however unlikely to change these cost.	Unlikely	Negligible	0
Construction Elements							
						Max Potential Cost Growth	15%

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
CE-1	Mobilization - Demobilization	• Accelerated schedule or harsh weather schedule?	• Accelerated schedule or harsh weather schedule?	Work is common to the NOD area. No concerns. Not emergency hurricane work.	Unlikely	Negligible	0
CE-2	Care and Diversion of Water	• Water care and diversion plan?	• Water care and diversion plan?	Cofferdam will be preventing water from GIWW on east side and water from west side from infiltrating the construction area. Work is common to the NOD area. There is some risk to the actual construction of the cofferdam, but it is unlikely it would occur. Not emergency hurricane work.	Unlikely	Significant	1
CE-3	Earthwork for Structures	• Accelerated schedule or harsh weather schedule?	• Accelerated schedule or harsh weather schedule?	Work is common to the NOD area. No concerns. Not emergency hurricane work. MII reflects marine environment when necessary.	Unlikely	Negligible	0
CE-4	Foundation Work	• High risk or complex construction elements, site access, in-water?	• High risk or complex construction elements, site access, in-water?	Soil conditions could require deeper foundation work. Work is common to the NOD area. Not emergency hurricane work. MII reflects marine environment and the complexity of construction. Quantity issue.	Likely	Negligible	1
CE-5	Seepage Control	• High risk or complex construction elements, site access, in-water?	• High risk or complex construction elements, site access, in-water?	Soil conditions could require additional seepage measures. Work is common to the NOD area. Not emergency hurricane work. MII reflects marine environment and the complexity of construciton. Quantity issue.	Likely	Negligible	1
CE-6	Embedded Metal Work	• High risk or complex construction elements, site access, in-water?	• Accelerated schedule or harsh weather schedule? • High risk or complex construction elements, site access, in-water?	Work is common to the NOD area. Not emergency hurricane work. MII reflects marine environment and the complexity of construction. Quantity issue.	Unlikely	Negligible	0
CE-7	Gates, Stop Logs and Associated Eq	• Special equipment or subcontractors needed?	• Special equipment or subcontractors needed?	Work is common to the NOD area. Not emergency hurricane work. Gates are simple to construct. Common methods reflected in MII>	Unlikely	Negligible	0
CE-8	Channel Excavation	• Unique construction methods?	• Unique construction methods?	Work is common to the MVN area. Special construction methods could be mandated but not likely to occur.	Unlikely	Marginal	0
CE-9	Concrete	• Accelerated schedule or harsh weather schedule?	• Accelerated schedule or harsh weather schedule?	Work is common to the MVN area. No concerns. Not emergency hurricane work. MII reflects marine environment when necessary. Special needs addressed in the MII.	Unlikely	Negligible	0
CE-10	0	• Accelerated schedule or harsh weather schedule?			Unlikely	Negligible	0

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
CE-11	0	• Accelerated schedule or harsh weather schedule?			Unlikely	Negligible	0
CE-12	Remaining Construction Items	• Special equipment or subcontractors needed?	• Special equipment or subcontractors needed?	Work is common to the MVN area. No concerns. Not emergency hurricane work. MII reflects marine environment when necessary. Electrical items are subcontracted in MII.	Unlikely	Negligible	0
CE-13	Planning, Engineering, & Design	• Accelerated schedule or harsh weather schedule?	• Accelerated schedule or harsh weather schedule?	Work is common to the MVN area. No concerns.	Unlikely	Negligible	0
CE-14	Construction Management	• Accelerated schedule or harsh weather schedule?	• Accelerated schedule or harsh weather schedule?	Work is common to the MVN area. No concerns.	Unlikely	Negligible	0
Quantities for Current Scope							
						Max Potential Cost Growth	20%
Q-1	Mobilization - Demobilization	• Level of confidence based on design and assumptions?	• Level of confidence based on design and assumptions?	Mobilization and Demobilization is common work in MVN. Project has both marine and road access. Low risk.	Unlikely	Negligible	0
Q-2	Care and Diversion of Water	• Sufficient investigations to develop quantities?	• Sufficient investigations to develop quantities?	Soil conditions could require deeper pilings for cofferdam. Team recommends likely risk (given topography) and marginal impact since cost of cofferdam is only 1/13th of the constuction estimate and would not generate an adjustment to the overall cost.	Likely	Significant	3
Q-3	Earthwork for Structures	• Sufficient investigations to develop quantities?	• Level of confidence based on design and assumptions? • Sufficient investigations to develop quantities?	General area of the structure and the backfill are generally well defined. There is a good opurtunity to obtain material within the 10 mile haul distance assumed. After borings are obtained the adjacent material may be found to be reasonable and be used as backfill.	Unlikely	Negligible	0
Q-4	Foundation Work	• Level of confidence based on design and assumptions?	• Sufficient investigations to develop quantities? • Level of confidence based on design and assumptions?	PDT discussed excavation concerns with disposal but marshcranes can handle, neglibile risk. As a result of borings concrete pile can change. Likely recommendation but a marginal impact since pilings, while expensive, would not cost that much more to go a bit deeper	Likely	Significant	3
Q-5	Seepage Control	• Sufficient investigations to develop quantities?	• Sufficient investigations to develop quantities?	Desgners are confident that footprint and the length of the sheets are conservative. Team recommends likely risk (given topography) and marginal impact since cost of cofferdam is only 1/13th of the constuction estimate and would not generate a huge hit to the overall cost.	Likely	Significant	3
Q-6	Embedded Metal Work	• Sufficient investigations to develop quantities?	• Sufficient investigations to develop quantities?	quantities could go up since the estimating method for this category are based off of a similar structure, whereas other categories were calculated specifically for this structure/channel work PDT feel that there is a likely risk to the embedded metals work but the cost impact is marginal since there is quite a bit of material in the current estimate	Likely	Significant	3
Q-7	Gates, Stop Logs and Associated Eq	• Level of confidence based on design and assumptions?	• Level of confidence based on design and assumptions?	Team is confident in amount of gates necessary to satisfy design criteria. unlikely/neglible decision by team	Unlikely	Marginal	0

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Q-8	Channel Excavation	• Sufficient investigations to develop quantities?	• Sufficient investigations to develop quantities?	Surveys have been obtained for the channel excavation. Dike costs could fluctuate some due to varying water depths in the disposal area. Minimal affect to cost. (This item is captured in the risk register developed by the PDT).	Possible	Marginal	1
Q-9	Concrete	• Level of confidence based on design and assumptions?	• Level of confidence based on design and assumptions?	Concrete quantities could change based on soil conditions and earthwork/foundation work. Team agrees on possible likelihood and marginal impact. Bigger fear for concrete is commodity cost.	Possible	Marginal	1
Q-10	0	• Level of confidence based on design and assumptions?			Unlikely	Negligible	0
Q-11	0	• Level of confidence based on design and assumptions?			Unlikely	Negligible	0
Q-12	Remaining Construction Items	• Level of confidence based on design and assumptions?	• Level of confidence based on design and assumptions?	A guidwall in lieu of protection dolphins could be required. The electrical items could increase significantly due to site specific work.	Likely	Significant	3
Q-13	Planning, Engineering, & Design	• Level of confidence based on design and assumptions?	• Level of confidence based on design and assumptions?	Quantity changes would not affect PED. Team agreed.	Unlikely	Negligible	0
Q-14	Construction Management	• Level of confidence based on design and assumptions?	• Level of confidence based on design and assumptions?	Quantity changes would not affect PED. Team agreed.	Unlikely	Negligible	0
Specialty Fabrication or Equipment							
						Max Potential Cost Growth	**50%**
FE-1	Mobilization - Demobilization	• Ability to reasonably transport?	• Ability to reasonably transport?	There is both marine and road access to site. PDT recommends Unlikely/Negligle.	Unlikely	Negligible	0
FE-2	Care and Diversion of Water	• Risk of specialty equipment functioning first time? Test?	• Risk of specialty equipment functioning first time? Test?	Cofferdam construction is pretty regular in coastal LA, contractors are familiar with materials and installation. Team said possible issue with cofferdams but cost impact is marginal.	Possible	Marginal	1
FE-3	Earthwork for Structures	• Ability to reasonably transport?	• Ability to reasonably transport?	Team feels comfortable in equipment used for earthwork, low risk item. PDT recommends Unlikely/Neglible.	Unlikely	Negligible	0
FE-4	Foundation Work	• Unusual parts, material or equipment manufactured or installed?	• Unusual parts, material or equipment manufactured or installed?	Concrete pile installation is a common practice in MVN. PDT recommends Unlikely/Negligible.	Unlikely	Negligible	0
FE-5	Seepage Control	• Unusual parts, material or equipment manufactured or installed?	• Unusual parts, material or equipment manufactured or installed?	Sheetpile installation is a common practive in MVN. PDT recommends Unlikely/Neglible.	Unlikely	Negligible	0

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
FE-6	Embedded Metal Work	• Unusual parts, material or equipment manufactured or installed?	• Unusual parts, material or equipment manufactured or installed?	Common items, PDT sees no risk with these under this risk category. PDT recommends Unlikely/Neglible.	Unlikely	Negligible	0
FE-7	Gates, Stop Logs and Associated Eq	• Unusual parts, material or equipment manufactured or installed?	• Unusual parts, material or equipment manufactured or installed?	Some PDT concern that gate size may be a problem or be delayed due to amount needed. PDT wishes to express a possible risk with significant cost impact if getting the gates to the site or even having them made is an issue.	Possible	Significant	2
FE-8	Channel Excavation	• Unusual parts, material or equipment manufactured or installed?	• Unusual parts, material or equipment manufactured or installed?	Typical dredge work and disposal methods. PDT recommends Unlikely/Marginal.	Unlikely	Marginal	0
FE-9	Concrete	• Unusual parts, material or equipment manufactured or installed?	• Unusual parts, material or equipment manufactured or installed?	PDT did not find issue with concrete mateiral or material supply. Recommend Unlikely/Negligible.	Unlikely	Negligible	0
FE-10	0	• Unusual parts, material or equipment manufactured or installed?			Unlikely	Negligible	0
FE-11	0	• Unusual parts, material or equipment manufactured or installed?			Unlikely	Negligible	0
FE-12	Remaining Construction Items	• Unusual parts, material or equipment manufactured or installed?	• Unusual parts, material or equipment manufactured or installed?	Materials associated with this line are readily available, not complicated to install. Recomend Unlikely/Negligble	Unlikely	Negligible	0
FE-13	Planning, Engineering, & Design	• Unusual parts, material or equipment manufactured or installed?	• Unusual parts, material or equipment manufactured or installed?	Normal work activities in the MVN.	Unlikely	Negligible	0
FE-14	Construction Management	• Unusual parts, material or equipment manufactured or installed?	• Unusual parts, material or equipment manufactured or installed?	Normal work activities in the MVN.	Unlikely	Negligible	0
Cost Estimate Assumptions							
						Max Potential Cost Growth	25%
CT-1	Mobilization - Demobilization	• Site accessibility, transport delays, congestion?	• Site accessibility, transport delays, congestion?	Project features both marine and road access. MII estimate	Unlikely	Marginal	0
CT-2	Care and Diversion of Water	• Assumptions related to prime and subcontractor markups/assignments?	• Reliability and number of key quotes? • Assumptions related to prime and subcontractor markups/assignments?	Sheetpile installation is a common practive in MVN. Crews and price quotes used are current and reasonable. National economy is in a slump, labor is readily available. PDT recommends Unlikely/Neglible.	Unlikely	Marginal	0
CT-3	Earthwork for Structures	• Site accessibility, transport delays, congestion?	• Site accessibility, transport delays, congestion?	All local features of earhtwork are detailed in MII. Crew and trucking costs are current. Assumption of haul distance is conservative assesment. Possiblity of onsite borrow which would reduce cost. Crews are paid above davis bacon. National economy is in a slump, labor is readily available.	Unlikely	Marginal	0

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
CT-4	Foundation Work	• Reliability and number of key quotes?	• Reliability and number of key quotes?	Sheetpile installation is a common practive in MVN. Crews and price quotes used are current and reasonable. Quotes compared to more than one source. PDT recommends National economy is in a slump, labor is readily available. Unlikely/Neglible.	Unlikely	Marginal	0
CT-5	Seepage Control	• Reliability and number of key quotes?	• Reliability and number of key quotes?	Sheetpile installation is a common practive in MVN. Crews and price quotes used are current and reasonable. Quotes compared to more than one source. PDT recommends National economy is in a slump, labor is readily available. Unlikely/Neglible.	Unlikely	Marginal	0
CT-6	Embedded Metal Work	• Reliability and number of key quotes?	• Reliability and number of key quotes?	Sheetpile installation is a common practive in MVN. Crews and price quotes used are current and reasonable. Quotes compared to more than one source. PDT recommends National economy is in a slump, labor is readily available. Unlikely/Neglible.	Unlikely	Marginal	0
CT-7	Gates, Stop Logs and Associated Eq	• Reliability and number of key quotes?	• Assumptions regarding crew, productivity, overtime? • Reliability and number of key quotes?	Material quote obtained from supplier. Crew and production assessed from other work in the MVN. National economy is in a slump, labor is readily available. Steel prices on the decline.	Unlikely	Marginal	0
CT-8	Channel Excavation	• Assumptions regarding crew, productivity, overtime?	• Assumptions related to prime and subcontractor markups/assignments? • Assumptions regarding crew, productivity, overtime?	Dredgin new construction is a common occurance in MVN with adequate historical data. National economy is in a slump, labor is readily available.	Unlikely	Marginal	0
CT-9	Concrete	• Reliability and number of key quotes?	• Reliability and number of key quotes?	Demand for concrete is low however demand does fluctuate. Materials are readily available.	Unlikely	Marginal	0
CT-10	0	• Reliability and number of key quotes?			Unlikely	Negligible	0
CT-11	0	• Reliability and number of key quotes?			Unlikely	Negligible	0
CT-12	Remaining Construction Items	• Reliability and number of key quotes?	• Assumptions related to prime and subcontractor markups/assignments? • Reliability and number of key quotes?	Electrical items are subcontracted in the MII. Other items are all likely to constructed with the prime contractor.	Unlikely	Marginal	0
CT-13	Planning, Engineering, & Design	• Reliability and number of key quotes?	• Reliability and number of key quotes?	Cost provided by Engineering Division	Unlikely	Negligible	0
CT-14	Construction Management	• Reliability and number of key quotes?	• Reliability and number of key quotes?	Cost provided by Construction Division	Unlikely	Negligible	0
External Project Risks							
						Max Potential Cost Growth	20%

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
EX-1	Mobilization - Demobilization	• Potential for market volatility impacting competition, pricing?	• Potential for market volatility impacting competition, pricing?	Potential for dredge equipmenet to come form far away however dredging quantity is small enough to allow smaller dredges to accomplish work. All other work needs readily available.	Unlikely	Marginal	0
EX-2	Care and Diversion of Water	• Potential for market volatility impacting competition, pricing?	• Potential for severe adverse weather? • Potential for market volatility impacting competition, pricing?	Could have storm impacts but considered negligilbe to cost. Material violatility could happen considering current trends and would have significant impact.	Likely	Significant	3
EX-3	Earthwork for Structures	• Potential for severe adverse weather?	• Potential for severe adverse weather?	The quantity of the earth needed is small therefore weather impacts are decreased. Material readily available.	Likely	Marginal	2
EX-4	Foundation Work	• Potential for severe adverse weather?	• Unanticipated inflations in fuel, key materials? • Potential for severe adverse weather?	Could have storm impacts but considered negligilbe to cost. Material violatility could happen considering current trends and would have significant impact.	Likely	Significant	3
EX-5	Seepage Control	• Potential for severe adverse weather?	• Unanticipated inflations in fuel, key materials? • Potential for severe adverse weather?	Could have storm impacts but considered negligilbe to cost. Material violatility could happen considering current trends and would have significant impacts..	Likely	Significant	3
EX-6	Embedded Metal Work	• Potential for severe adverse weather?	• Unanticipated inflations in fuel, key materials? • Potential for severe adverse weather?	Could have storm impacts but considered negligilbe to cost. Material violatility could happen but is not likely to happen considering current trends.	Likely	Significant	3
EX-7	Gates, Stop Logs and Associated Eq	• Potential for market volatility impacting competition, pricing?	• Potential for market volatility impacting competition, pricing?	Could have storm impacts but considered negligilbe to cost. Material violatility could happen but is not likely to happen considering current trends.	Likely	Significant	3
EX-8	Channel Excavation	• Potential for market volatility impacting competition, pricing?	• Unanticipated inflations in fuel, key materials? • Potential for severe adverse weather? • Potential for market volatility impacting competition, pricing?	Fuel is extremely volatile and is the main driver in dredge cost. PDT discussed. Market is wide open with protected waters and shallow dredging depth coupled with small dredge quantity. Many contractors available to complete dredging.	Likely	Significant	3
EX-9	Concrete	• Potential for severe adverse weather?	• Unanticipated inflations in fuel, key materials? • Potential for severe adverse weather?	Could have storm impacts but considered negligilbe to cost. Material violatility could happen but is not likely to happen considering current trends.	Likely	Significant	3
EX-10	0	• Potential for severe adverse weather?			Unlikely	Negligible	0
EX-11	0	• Potential for severe adverse weather?			Unlikely	Negligible	0
EX-12	Remaining Construction Items	• Potential for market volatility impacting competition, pricing?	• Potential for market volatility impacting competition, pricing?	Weather would have minimal impacts. Electrical supply cost could increase but not likely. PDT discussion.	Unlikely	Marginal	0
EX-13	Planning, Engineering, & Design	• Political influences, lack of support, obstacles?	• Political influences, lack of support, obstacles?	Political support for project coupled with marsh creation and water control. Pluses.	Unlikely	Negligible	0
EX-14	Construction Management	• Potential for severe adverse weather?	• Potential for severe adverse weather?	Should have no affect.	Unlikely	Negligible	0

Calcasieu Lock TSP
Feasibility (Recommended Plan)
Abbreviated Risk Analysis

Potential Risk Areas

Typical Risk Elements

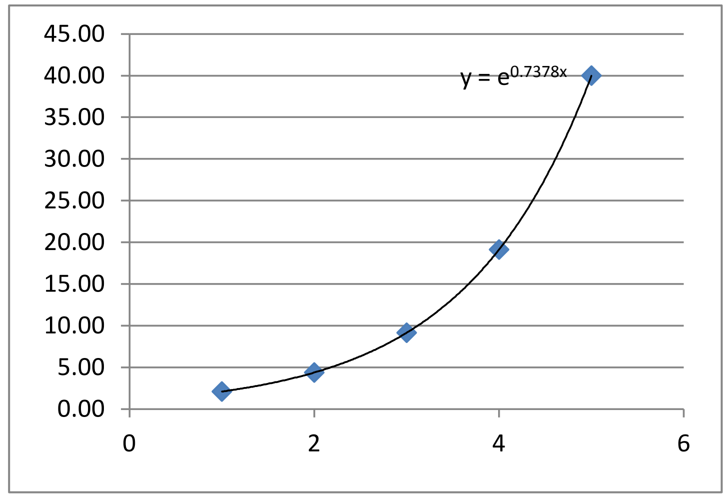
	Mobilization - Demobilization	Care and Diversion of Water	Earthwork for Structures	Foundation Work	Seepage Control	Embedded Metal Work	Gates, Stop Logs and Associated E	Channel Excavation	Concrete	0	0	Remaining Construction Iter	Planning, Engineering, & Design	Construction Management
Project Scope Growth	-	1	1	1	1	1	1	1	1	-	-	-	1	-
Acquisition Strategy	2	2	2	2	2	2	2	2	2	-	-	2	-	-
Construction Elements	-	1	-	1	1	-	-	-	-	-	-	-	-	-
Quantities for Current Scope	-	3	-	3	3	3	-	1	1	-	-	3	-	-
Specialty Fabrication or Equipment	-	1	-	-	-	-	2	-	-	-	-	-	-	-
Cost Estimate Assumptions	-	-	-	-	-	-	-	-	-	-	-	-	-	-
External Project Risks	-	3	2	3	3	3	3	3	3	-	-	-	-	-

Project Scope Growth

Max Potenital Cost Growth 40 %

x	y	
0	0	0.00%
1	2.09	2.09%
2	4.37	4.37%
3	9.15	9.15%
4	19.13	19.13%
5	40.00	40.00%

y	=	a^x
a	=	y^(1/x)
a	=	2.091279

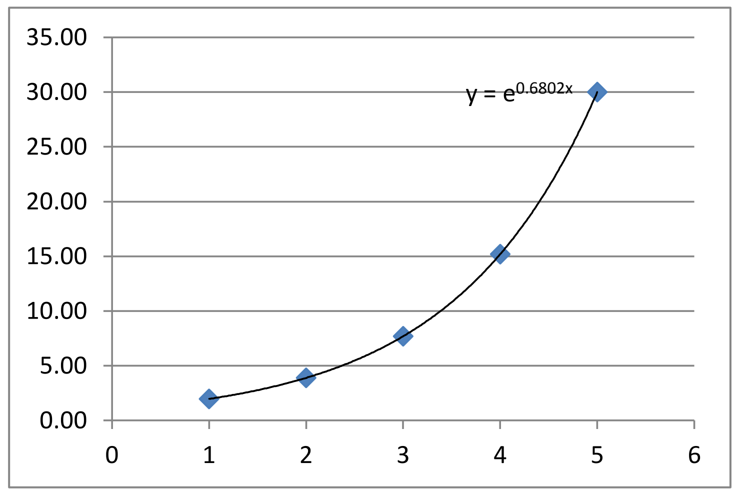


Acquisition Strategy

Max Potenital Cost Growth 30 %

x	y	
0	0	0.00%
1	1.97	1.97%
2	3.90	3.90%
3	7.70	7.70%
4	15.19	15.19%
5	30.00	30.00%

y	=	a^x
a	=	y^(1/x)
a	=	1.97435

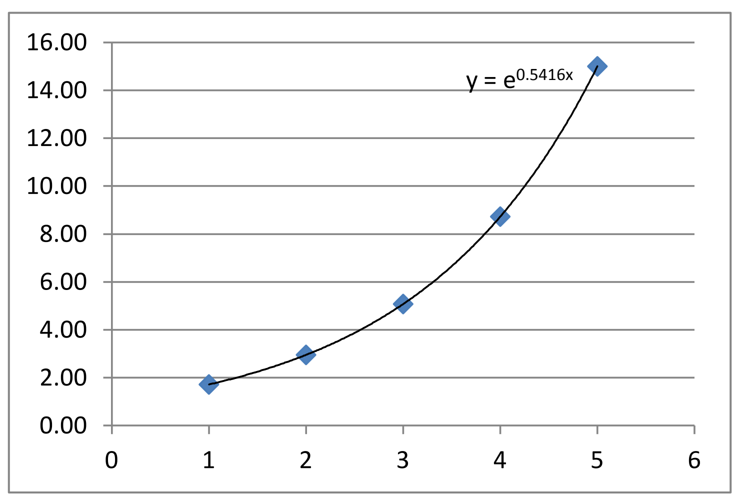


Construction Elements

Max Potenital Cost Growth 15 %

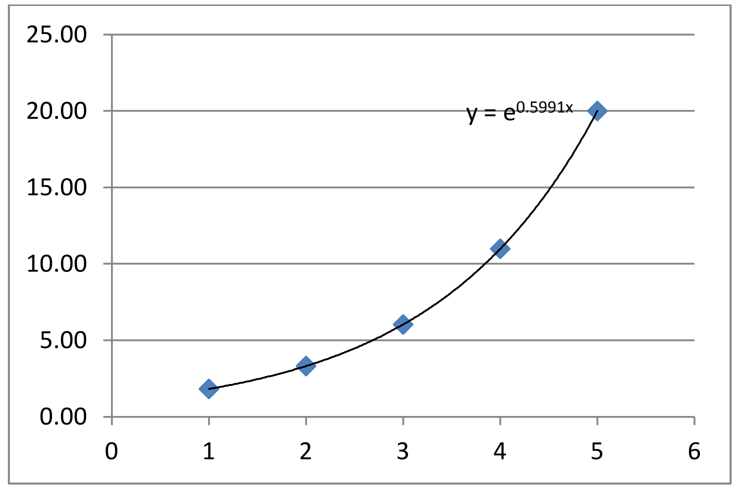
x	y	
0	5	5.00%
1	1.72	6.72%
2	2.95	7.95%
3	5.08	10.08%
4	8.73	13.73%
5	15.00	20.00%

y	=	a^x
a	=	y^(1/x)
a	=	1.718772



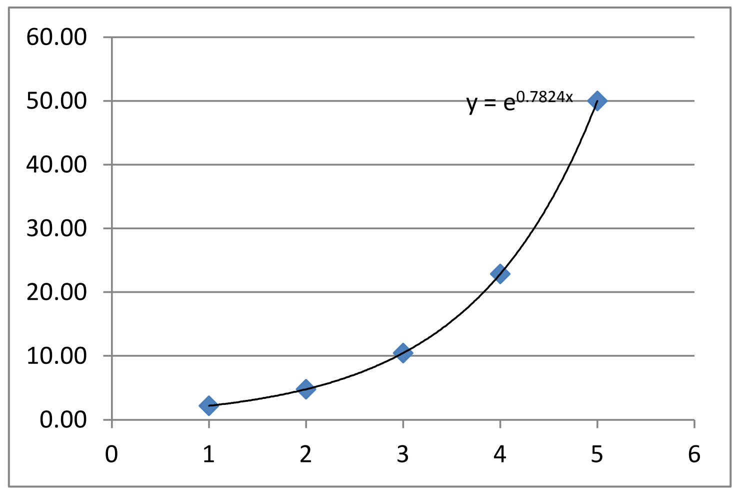
Quantities	Max Potenital Cost Growth	20 %	
	x	y	
	0	0	0.00%
	1	1.82	1.82%
	2	3.31	3.31%
	3	6.03	6.03%
	4	10.99	10.99%
	5	20.00	20.00%

y = a^x
a = y^(1/x)
a = 1.820564



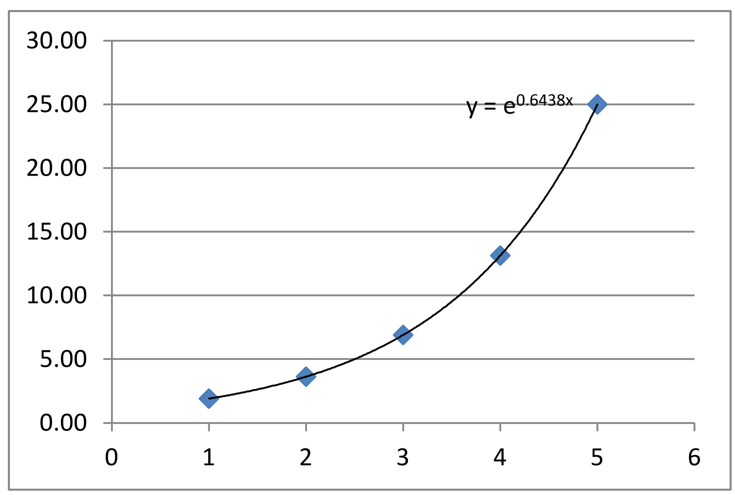
Fab or Equip	Max Potenital Cost Growth	50 %	
	x	y	
	0	0	0.00%
	1	2.19	2.19%
	2	4.78	4.78%
	3	10.46	10.46%
	4	22.87	22.87%
	5	50.00	50.00%

y = a^x
a = y^(1/x)
a = 2.186724



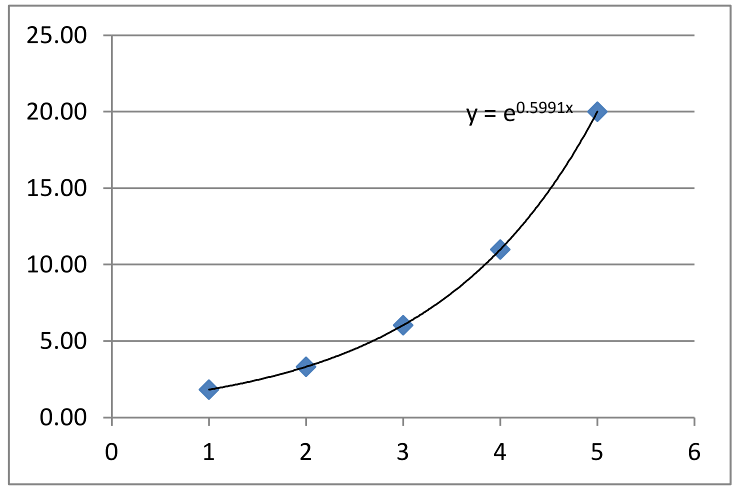
Cost Est Assumptions	Max Potenital Cost Growth	25 %	
	x	y	
	0	0	0.00%
	1	1.90	1.90%
	2	3.62	3.62%
	3	6.90	6.90%
	4	13.13	13.13%
	5	25.00	25.00%

y = a^x
a = y^(1/x)
a = 1.903654



	Max Potenital Cost		
External Risks	Growth	20	%
	x	y	
	0	0	0.00%
	1	1.82	1.82%
	2	3.31	3.31%
	3	6.03	6.03%
	4	10.99	10.99%
	5	20.00	20.00%

y	=	a^x
a	=	y^(1/x)
a	=	1.820564



Calcasieu Lock TSP

Feasibility (Recommended Plan)

Abbreviated Risk Analysis

	Project Scope Growth		Acquisition Strategy		Construction Elements		Quantities for Current Scope		Specialty Fabrication or Equipment		Cost Estimate Assumptions		External Project Risks		Σ	Σ of $
	40%		30%		15%		20%		50%		25%		20%		200%	
Mobilization - Demobilization	0.00%	$ -	3.90%	$ 60,985	5.00%	$ 78,224	0.00%	$ -	0.00%	$ -	0.00%	$ -	0.00%	$ -		$ 139,209
Care and Diversion of Water	2.09%	$ 28,997	3.90%	$ 54,050	6.72%	$ 93,162	6.03%	$ 83,669	2.19%	$ 30,321	0.00%	$ -	6.03%	$ 83,669		$ 373,868
Earthwork for Structures	2.09%	$ 5,342	3.90%	$ 9,957	5.00%	$ 12,771	0.00%	$ -	0.00%	$ -	0.00%	$ -	3.31%	$ 8,466		$ 36,536
Foundation Work	2.09%	$ 15,220	3.90%	$ 28,370	6.72%	$ 48,899	6.03%	$ 43,917	0.00%	$ -	0.00%	$ -	6.03%	$ 43,917		$ 180,323
Seepage Control	2.09%	$ 6,054	3.90%	$ 11,285	6.72%	$ 19,451	6.03%	$ 17,469	0.00%	$ -	0.00%	$ -	6.03%	$ 17,469		$ 71,729
Embedded Metal Work	2.09%	$ 20,558	3.90%	$ 38,320	5.00%	$ 49,152	6.03%	$ 59,319	0.00%	$ -	0.00%	$ -	6.03%	$ 59,319		$ 226,667
Gates, Stop Logs and Associated Eq	2.09%	$ 29,144	3.90%	$ 54,323	5.00%	$ 69,680	0.00%	$ -	4.78%	$ 66,639	0.00%	$ -	6.03%	$ 84,092		$ 303,878
Channel Excavation	2.09%	$ 31,611	3.90%	$ 58,922	5.00%	$ 75,579	1.82%	$ 27,519	0.00%	$ -	0.00%	$ -	6.03%	$ 91,211		$ 284,842
Concrete	2.09%	$ 21,026	3.90%	$ 39,192	5.00%	$ 50,271	1.82%	$ 18,304	0.00%	$ -	0.00%	$ -	6.03%	$ 60,668		$ 189,461
0	0.00%	$ -	0.00%	$ -	5.00%	$ -	0.00%	$ -	0.00%	$ -	0.00%	$ -	0.00%	$ -		$ -
0	0.00%	$ -	0.00%	$ -	5.00%	$ -	0.00%	$ -	0.00%	$ -	0.00%	$ -	0.00%	$ -		$ -
Remaining Construction Items	0.00%	$ -	3.90%	$ 61,743	5.00%	$ 79,197	6.03%	$ 95,578	0.00%	$ -	0.00%	$ -	0.00%	$ -		$ 236,518
		$ 157,953.03		$ 417,145.77		$ 576,385.81		$ 345,774.57		$ 96,959.46		$ -		$ 448,810.78	$ 2,043,029.41	$ 2,043,029
		$ 10,701,368.95		$ 10,701,368.95		$ 10,701,368.95		$ 10,701,368.95		$ 10,701,368.95		$ 10,701,368.95		$ 10,701,368.95	$ 10,701,368.95	$10,701,368.95
		1.48%		3.90%		5.39%		3.23%		0.91%		0.00%		4.19%	19.09%	19.09% Check

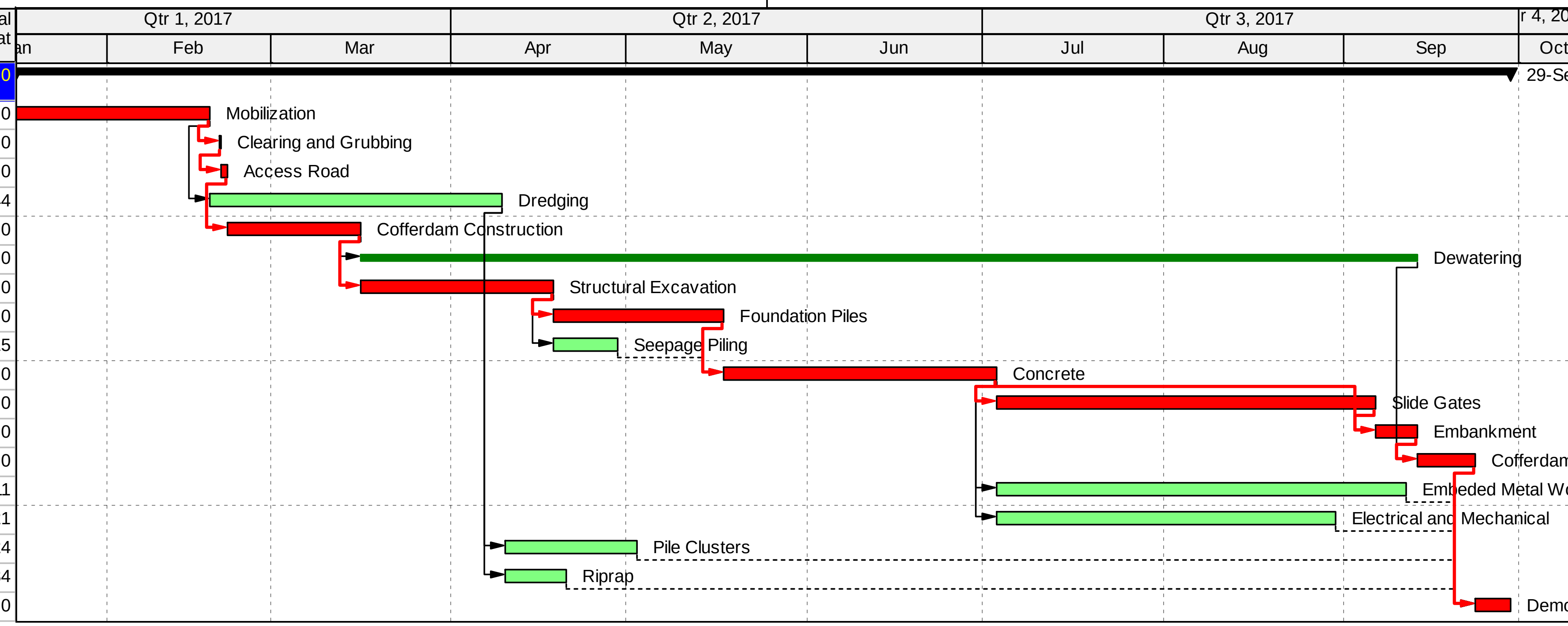
<u>Civil Works Work Breakdown Structure</u> **(CWWBS)**
Reference ETL 110-2-573 03 Sep 08, Table 2-1.

01 LANDS AND DAMAGES
01 18 GENERAL REVALUATION REPORT (GRR)
01 19 LIMITED REVALUATION REPORT (LRR)
01 20 PROJECT DESIGN MEMORANDUM
01 21 FEATURE DESIGN MEMORANDUM
01 23 CONSTRUCTION CONTRACT(S) DOCUMENTS
02 RELOCATIONS
02 01 ROADS, Construction Activities
02 02 RAILROADS, Construction Activities
02 03 CEMETERIES, UTILITIES, AND STRUCTURES, Construction Activities
03 RESERVOIRS
04 DAMS
04 01 MAIN DAM
04 02 SPILLWAY
04 03 OUTLET WORKS
04 04 POWER INTAKE WORKS
04 05 AUXILIARY DAMS
04 06 MUNICIPAL AND INDUSTRIAL WATER DELIVERY FACILITIES
05 LOCKS
06 FISH AND WILDLIFE FACILITIES
06 01 FISH FACILITIES AT DAMS
06 02 FISH HATCHERY, (Including Trapping and Release Facilities)
06 03 WILDLIFE FACILITIES AND SANCTUARIES
07 POWER PLANT
07 01 POWERHOUSE
07 02 TURBINES AND GENERATORS
07 03 ACCESSORY ELECTRICAL EQUIPMENT
07 04 MISCELLANEOUS POWER PLANT EQUIPMENT
07 05 TAILRACE
07 06 SWITCHYARD
08 ROADS, RAILROADS, AND BRIDGES
08 01 ROADS
08 02 RAILROADS
09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)
09 01 CHANNELS
09 02 CANALS
10 BREAKWATERS AND SEAWALLS
11 LEVEES AND FLOODWALLS
11 01 LEVEES
11 02 FLOODWALLS
12 NAVIGATION, PORTS AND HARBORS
12 01 PORTS
12 02 HARBORS
13 PUMPING PLANT
14 RECREATION FACILITIES
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES
16 BANK STABILIZATION
17 BEACH REPLENISHMENT

18 CULTURAL RESOURCE PRESERVATION
19 BUILDINGS, GROUNDS, AND UTILITIES
20 PERMANENT OPERATING EQUIPMENT
30 PLANNING, ENGINEERING, AND DESIGN
30 11 PROJECT COOPERATION AGREEMENT
30 12 PROJECT MANAGEMENT PLAN
30 18 GENERAL REEVALUATION REPORT (GRR)
30 19 LIMITED REEVALUATION REPORT (LRR)
30 20 PROJECT DESIGN MEMORANDUM
30 21 FEATURE DESIGN MEMORANDUM
30 23 CONSTRUCTION CONTRACT(S) DOCUMENTS
30 24 VALUE ENGINEERING ANALYSIS DOCUMENTS
30 25 PROJECT OR FUNCTIONAL ELEMENT CLOSEOUT
30 26 PROGRAMS AND PROJECT MANAGEMENT DOCUMENTS
31 CONSTRUCTION MANAGEMENT
31 12 PROJECT MANAGEMENT PLAN
31 23 CONSTRUCTION CONTRACT(S) DOCUMENTS
31 26 PROGRAMS AND PROJECT MANAGEMENT DOCUMENTS
32 HAZARDOUS AND TOXIC WASTE
32 01 MOB, DEMOB & PREPARATORY WORK
32 02 SYSTEMS STARTUP/OPERATIONS/MAINTENANCE
32 03 INSTITUTIONAL ACTIONS
32 04 SURFACE WATER CONTROL
32 05 COLLECTION & INJECTION OF GROUND WATER
32 06 COLLECTION & DISPOSAL OF WASTES
32 07 CONTAIN & RESTORE CONTAMINATED GROUND WATER
32 08 CONTAINMENT FOR WASTES
32 10 TREAT-WASTES/CONTAMINATED SOIL & WATER
32 11 AIR POLLUTION AND LANDFILL GAS CONTROL
32 12 INNOVATIVE TECHNOLOGIES
32 13 SUPPORTING FACILITIES
32 14 PRIME CONTRACTOR'S INDIRECT COST

SCHEDULE

Activity ID	Activity Name	Original Duration	Start	Finish	Total Float
Total		221	16-Jan-17	29-Sep-17	0
A1000	Mobilization	30	16-Jan-17	18-Feb-17	0
A1005	Clearing and Grubbing	1	20-Feb-17	20-Feb-17	0
A1010	Access Road	1	20-Feb-17	21-Feb-17	0
A1020	Dredging	50	18-Feb-17	09-Apr-17	144
A1030	Cofferdam Construction	20	21-Feb-17	16-Mar-17	0
A1040	Dewatering	155	16-Mar-17	13-Sep-17	0
A1050	Structural Excavation	28	16-Mar-17	18-Apr-17	0
A1060	Foundation Piles	25	18-Apr-17	17-May-17	0
A1070	Seepage Piling	10	18-Apr-17	29-Apr-17	15
A1080	Concrete	40	17-May-17	03-Jul-17	0
A1085	Slide Gates	56	03-Jul-17	06-Sep-17	0
A1090	Embankment	6	06-Sep-17	13-Sep-17	0
A1100	Cofferdam Removal	9	13-Sep-17	23-Sep-17	0
A1110	Embeded Metal Work	60	03-Jul-17	11-Sep-17	11
A1120	Electrical and Mechanical	50	03-Jul-17	30-Aug-17	21
A1130	Pile Clusters	20	10-Apr-17	02-May-17	124
A1140	Riprap	10	10-Apr-17	20-Apr-17	134
A1150	Demobilization	5	23-Sep-17	29-Sep-17	0



Remaining Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | Summary

TASK filter: All Activities

TPCS

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Calcasieu River Lock Study
PROJECT NO: 108849
LOCATION: Calcasieu Parish, LA

DISTRICT: MVN New Orleans District PREPARED: 3/24/2014
POC: CHIEF, COST ENGINEERING, THOMAS D. MURPHY, P.E.

This Estimate reflects the scope and schedule in report; Calcasieu River Lock Study Report

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
						Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15				Spent Thru: 18-Mar-14				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
06	FISH & WILDLIFE FACILITIES	$790	$96	12.14%	$886	3.4%	$817	$99	$916	$0		$832	$101	$933
15	FLOODWAY CONTROL & DIVERSION STR	$10,701	$2,413	22.55%	$13,114	3.4%	$11,065	$2,495	$13,560	$0		$11,329	$2,555	$13,884
	CONSTRUCTION ESTIMATE TOTALS:	$11,491	$2,509		$14,000	3.4%	$11,882	$2,594	$14,476	$0		$12,162	$2,656	$14,817
01	LANDS AND DAMAGES	$95	$33	34.80%	$128	3.4%	$98	$34	$132	$0		$98	$34	$132
30	PLANNING, ENGINEERING & DESIGN	$1,149	$85	7.37%	$1,234	7.5%	$1,235	$91	$1,326	$0		$1,273	$94	$1,367
31	CONSTRUCTION MANAGEMENT	$919	$46	5.00%	$965	3.3%	$950	$47	$997	$0		$972	$49	$1,021
	PROJECT COST TOTALS:	$13,654	$2,673	20%	$16,327		$14,165	$2,767	**$16,932**	$0		$14,505	$2,832	$17,338

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CHIEF, COST ENGINEERING, THOMAS D. MURPHY, P.E.

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PROJECT MANAGER, JEFFREY J. VARISCO

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CHIEF, REAL ESTATE, LINDA LABURE

CHIEF, PLANNING, THOMAS CRUMP

CHIEF, ENGINEERING, MARK R. HOAGUE, P.E.

CHIEF, OPERATIONS, CHRIS ACCARDO

CHIEF, CONSTRUCTION, STUART S. WAITS, P.E.

CHIEF, CONTRACTING, TIMOTHY BLACK

CHIEF, PM-PB, MARK WINGATE

CHIEF, DPM, GARY HAWKINS

ESTIMATED FEDERAL COST:	**100%**	**$17,338**
ESTIMATED NON-FEDERAL COST:	**0%**	**$0**
ESTIMATED TOTAL PROJECT COST:		**$17,338**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Calcasieu River Lock Study
LOCATION: Calcasieu Parish, LA
This Estimate reflects the scope and schedule in report; Calcasieu River Lock Study Report

DISTRICT: MVN New Orleans District PREPARED: 3/24/2014
POC: CHIEF, COST ENGINEERING, THOMAS D. MURPHY, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 3/18/2014				Program Year (Budget EC): 2016								
		Effective Price Level: 3/18/2014				Effective Price Level Date: 1 OCT 15								
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 1													
06	FISH & WILDLIFE FACILITIES	$790	$96	12.14%	$886	3.4%	$817	$99	$916	2017Q1	1.9%	$832	$101	$933
15	FLOODWAY CONTROL & DIVERSION STRU	$10,701	$2,413	22.55%	$13,114	3.4%	$11,065	$2,495	$13,560	2017Q2	2.4%	$11,329	$2,555	$13,884
							$0							
	CONSTRUCTION ESTIMATE TOTALS:	$11,491	$2,509	22%	**$14,000**		$11,882	$2,594	$14,476			$12,162	$2,656	$14,817
01	LANDS AND DAMAGES	$95	$33	34.80%	$128	3.4%	$98	$34	$132	2016Q1	0.0%	$98	$34	$132
30	PLANNING, ENGINEERING & DESIGN													
0.0%	Project Management	$0	$0	7%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning & Environmental Compliance	$0	$0	7%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
7.0%	Engineering & Design	$804	$59	7%	$863	7.5%	$864	$64	$928	2016Q3	2.1%	$882	$65	$947
0.0%	Reviews, ATRs, IEPRs, VE	$0	$0	7%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Life Cycle Updates (cost, schedule, risks)	$0	$0	7%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Contracting & Reprographics	$0	$0	7%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
3.0%	Engineering During Construction	$345	$25	7%	$370	7.5%	$371	$27	$398	2017Q2	5.4%	$391	$29	$419
0.0%	Planning During Construction	$0	$0	7%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	7%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management	$689	$34	5%	$723	3.3%	$712	$36	$748	2017Q2	2.4%	$729	$36	$765
1.0%	Project Operation:	$115	$6	5%	$121	3.3%	$119	$6	$125	2017Q2	2.4%	$122	$6	$128
1.0%	Project Management	$115	$6	5%	$121	3.3%	$119	$6	$125	2017Q2	2.4%	$122	$6	$128
	CONTRACT COST TOTALS:	$13,654	$2,673		**$16,327**		$14,165	$2,767	$16,932			$14,505	$2,832	**$17,338**

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX M

HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

NOTE: Additional information relating to Hazardous, Toxic and Radioactive Waste of the Calcasieu Lock Feasibility Study is available upon request by contacting the New Orleans District Office at (504) 862-2201.

Phase I - Environmental Site Assessment Supplement

Calcasieu Lock Improvements
Calcasieu Parish, Louisiana

Prepared for:

U.S. Army Corps of Engineers
New Orleans District
New Orleans Louisiana

U.S. Army Corps of Engineers
St. Louis District
June 2013

Phase I - Environmental Site Assessment Supplement
Calcasieu Lock Improvements
Calcasieu Parish, Louisiana

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Phase I - Environmental Site Assessment Supplement
Calcasieu Lock Improvements
Calcasieu Parish, Louisiana
June 2013

Executive Summary

The objective of this limited Phase I Environmental Site Assessment (ESA) is to satisfy the All Appropriate Inquiry (AAI) requirements set by the Environmental Protection Agency to identify, to the extent feasible pursuant to the process described herein, recognized environmental conditions (RECs) in connection with a given property(s).

There are presently three alternatives proposed for the marsh area separating the GIWW and the Black Bayou immediately south of the existing Calcasieu Lock. A review of the reasonably ascertainable government records and telephone interviews of state and local officials revealed nothing of concern regarding HTRW materials or RECs within a two-mile radius of the project site. Historical topographic maps starts talking show the project site has always been an undeveloped marsh and historical aerial photographs show no evidence of surface staining, dumping, industrial land use, etc. that might indicate the presence of an REC.

A site inspection was conducted and no HTRW materials or RECs were observed or discovered at the sites of the three proposed alternatives or adjacent properties and concludes that a Phase II assessment is not necessary.

Purpose

The purpose of this document is to update and supplement the environmental assessment information found in the *Land-Use History of the Calcasieu Lock Facility and the Immediate Vicinity, Calcasieu Parish, Louisiana, August 2002* authored by R. Christopher Goodwin & Associates, Inc. This report is intended to serve as a modified Phase I Environmental Site Assessment to identify, to the extent feasible in the absence of sampling and analysis, the presence of recognized environmental conditions (RECs) within the scope of the U.S. Environmental Protection Agency's (EPA) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

The U.S. Army Corps of Engineers (USACE) regulations (ER-1165-132) and District policy requires procedures be established to facilitate early identification and appropriate consideration of potential hazardous, toxic, or radioactive waste (HTRW) in reconnaissance, feasibility, preconstruction engineering and design, land acquisition, construction, operations and maintenance, repairs, replacement, and rehabilitation phases of water resources studies or projects by conducting Phase I ESA. USACE specifies that these assessments follow the process/standard practices for conducting Phase I ESA's published by the American Society for Testing and Materials (ASTM).

This limited Phase I environmental site assessment was performed in general conformance with the scope and limitations of the ASTM standards E-1527-05 and E1528-06 and the Standards and Practices for All Appropriate Inquiries (AAI), 40 CFR Part 312. The information was obtained through reviews of readily available electronic records, reports, environmental databases and telephone interviews.

Project Description

Calcasieu Lock is located in the southwest corner of Louisiana approximately ten miles south of the City of Lake Charles in Calcasieu Parish. See Figure 1 attached. The structure sits at the Calcasieu River just east of the Calcasieu Ship Channel and is a feature of the Gulf Intracoastal Waterway (GIWW) that parallels the Gulf of Mexico coast. Calcasieu Lock serves as the entrance to the deep-water channel connecting the City of Lake Charles to the Gulf of Mexico and functions as a guard lock to prevent salt water in the ship channel from flowing east along the GIWW into the Mermentau Basin.

Completed in 1950, Calcasieu Lock is 13 ft. wide, 75 ft. deep, 1,206 ft. long and is reportedly structurally sound. However, navigation delays are occurring due to its authorized use to drain floodwaters from the Mermentau River Basin during flood events. A reconnaissance study completed in 1992, determined a need for capacity increases at Bayou Sorrel and Calcasieu Locks. The Calcasieu Lock Section 905(b) analysis found a favorable benefit-cost ratio and recommended proceeding with feasibility phase studies. The purpose of the current study is to determine the feasibility of reducing navigation delays caused by drainage events at the Calcasieu Lock.

There are presently three alternatives proposed for the marsh area separating the GIWW and the Black Bayou immediately south of the existing lock:

1. dredging a channel and constructing a new 75 foot gated structure; Figure 2.1
2. dredging a channel and constructing a pump station; Figure 2.2
3. dredging a channel in Black Bayou, installing additional culverts and constructing a pump station near the existing NCRS water control structure; Figure 2.3

Project Site Characteristics

The area is characterized as a brackish marsh with thick P*hragmites australis* (a tall reed) almost continuously along the GIWW and Black Bayou. Also found along the banks of the Black Bayou side channel are *Distichlis spicata* (saltgrass) and *Spartina alterniflora* (smooth cordgrass).

Forest is present along the south side of the lock on higher ground and extends south into the marsh along ridges. Tree species include Oak, Pine, Hackberry and Chinese tallowtree. The bayou water depth ranges between 1.5 ft and 5 ft. The soils are generally described as clayey with very slow infiltration rates, a high water table or shallow to an impervious layer.

Site Inspection

Using an airboat, the project area was inspected by Mr. Michael Henry, Industrial Hygienist, CEMVS-EC-EQ during the Wetland Value Assessment (WVA) on 13 December 2012. Accompanying him were Mr.Tim George, Real Estate Specialist, CEMVS-PD-C; Mr.Troy Mallach, USDA-NCRS, Baton Rouge; and Ms. Lisa Abernathy, NOAA-NMFS, Baton Rouge. Photographs taken during this inspection are attached.

No HTRW materials or RECs were observed or discovered during the site inspection.

Records Review

A search of reasonably ascertainable government records was conducted by Environmental Data Resources, Inc (EDR), a contractor specializing in environmental records review. The records search was designed to meet EPA's Standards and Practices for All Appropriate Inquiries (40 CFR Part 312) and the ASTM Standard Practice for Environmental Site Assessments (E 1527-05).

The EDR Radius Map Report found in Appendix A. The records review yielded the following sites within a two-mile radius of the project site. As shown on Figure 4, the majority of the sites are located approximately 1 mile northeast of the project site. Although there are no sites identified within the areas of the alternatives, it is noted the Calcasieu Lock was identified by the Federal ERNS database.

Environmental Records	Sites Identified	Database Description
RCRA non-gen	1	Resource Conservation and Recovery Act
RCRA-LQG	1	Large quantity generator:
RCRA-SQG	3	Small quantity generator
Federal ERNS	34	Emergency response organization system
UST	2	Underground storage tanks
SPI LLS	19	Emergency release reports
TRIS	2	Toxic Chemical Release Inventory System
TSCA	2	Manufacturers and importers on the Toxic Substances inventory
FTTS		Enforcement and compliance information
PADS	1	PCB generators, transporters, storers, brokers and disposers
FINDS	18	Facility Index System
RMP	2	Risk management plans for flammable and/or toxic substances
NPDES	8	National pollutant discharge elimination system
AIRS	6	Aerometric information retrieval system (air permits)
US AIRS	4	Federal air permits
ASBESTOS	1	Asbestos demolition and renovation projects

Additional Environmental Record Sources

Topographic Maps

Topographic maps collected by EDR from the United States Geologic Survey website, were reviewed for evidence of past use and activitieswhich could be of concern. Maps from 1932, 1955, 1975 and 1994 all show the site as swampy marsh. The EDR Historical Topographic Map Report is included in Appendix B.

Aerial Photographs

A search for historical aerial photographs was performed by EDR produced aerial imagery from 1975, 1978, 1989, 1994 and 1998. It appears, from the photographs, the project site has always been an undeveloped marsh. No evidence of surface staining, dumping, industrial land use, etc. that might indicate the presence of an REC are apparent in the photos.

The EDR aerial photos are found in Appendix C.

Interviews

Telephone interviews were conducted to obtain information indicating RECs in connection with this site. The content of the questions asked followed the questionnaire format of ASTM 1528.

Louisiana Department of Environmental Quality
Office of Environmental Assessment
Southwest Regional Office
Lake Charles, LA 70615
Scott Wilkinson, Regional Supervisor
Surveillance Division
337-491-2667
Contacted May 28, 2013: No HTRW issues reported

Calcasieu Parish Police Jury
Timothy Conner, Parish Engineer,
337-721-4100
Contacted May 23, 2013: No HTRW issues reported.

US Army Corps of Engineers
Calcasieu Lock
Kevin Galley, Lockmaster
337-477-1482
Contacted May 28, 2013: No HTRW issues reported.

Conclusions

This assessment did not reveal any evidence of RECs and found the likelihood of encountering HTRW materials in connection with this project unlikely. A Phase II ESA is not necessary for the proposed project alternatives.

Limiting Conditions

U.S. Army Corps of Engineers, Environmental Engineering Section, should be contacted with any known or suspected variations from the conditions described herein. If future development of the property indicates the presence of hazardous or toxic materials, USACE should be notified to perform a re-evaluation of the environmental conditions.

The scope of this assessment did not include any additional environmental investigation, not outlined herein, or analyses for the presence or absence of hazardous or toxic materials in the soil, ground water, surface water, or air, in on, under or above the subject tract.

This site assessment was performed in accordance with generally accepted practices of consultants undertaking similar studies at the same time and in the same geographical area, and USACE observed that degree of care and skill generally exercised by consultants under similar circumstances and conditions. The findings and conclusions stated herein must be considered not as scientific certainties, but rather as professional opinions concerning the significance of the limited data gathered during the course of the environmental site assessment. No other warranty, express or implied, is made.

Specifically, USACE does not and cannot represent that the site contains no hazardous waste or material, oil (including petroleum products), or other latent condition beyond that observed a by USACE during its site assessment.

The observations described in this report were made under the conditions stated herein. The conclusions presented in the report were based solely upon the services described therein, and not on scientific tasks or procedure beyond the scope of described services or the time and budgetary constraints imposed by the client. Furthermore, such conclusions are based solely on site condition, and rules and regulations, which were in effect, at the time of the study.

In preparing this report, USACE relied on certain information provided by state and local officials and other parties referenced therein, and on information contained in the files of state and/or local agencies available to USACE at the time of the site assessment. Although there may have been some degree of overlap in the information provided by these various sources, an attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this site assessment was not made.

Observations were made of the site and of structures on the site as indicated within the report. Where access to portions of the site or to structures on the site was unavailable or limited, USACE renders no opinion as to the presence of indirect evidence relating to hazardous waste or material or oil, or other petroleum products in that portion of the site or structure. In addition, USACE renders no opinion as to the presence of hazardous waste or material, oil or other petroleum products or to the presence of indirect evidence relating to hazardous material, oil, or petroleum products where direct observation of the interior walls, floor, roof, or ceiling of a structure on a site was obstructed by objects or coverings on or over these surfaces.

Unless otherwise specified in the report, USACE did not perform testing or analyses to determine if certain report the presence or concentration of asbestos, radon, formaldehyde, lead-based paint, lead in drinking water, electromagnetic fields (EMFs) or polychlorinated biphenyls (PCBs) at the site or in the environment at the site.

The purpose of this report was to assess the physical characteristics of the subject site with respect to the presence in the environment of hazardous waste or material, oil, or petroleum products. No specific attempt was made to check on the compliance of present or past owners or operators of the site with federal, state, or local laws and regulations, environmental or otherwise.

Qualifications

USACE EC-HE personnel have specific qualifications based on education, training and experience to assess a property of the nature, history, and setting of the subject properties and declare , to the best of our professional knowledge and belief meet the definitions of Environmental Professionals as defined under 40 CFR 312.

Report prepared by: KING.MICHAEL.A.1245772218 Digitally signed by KING.MICHAEL.A.1245772218 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=KING.MICHAEL.A.1245772218 Date: 2013.06.10 09:20:41 -05'00'

Michael A. King, P.E.
Environmental Engineer
CEMVS- EC-EQ

I declare that, to the best of my professional knowledge and belief, I meet the definition of Environmental Professional as defined in 40 CFR 312.10. I have the specific qualifications based on education, training, and experience to assess a property of the nature, history, and setting of the subject property. I have developed and performed the all appropriate inquiries in conformance with the standards and practices set forth in 40 CFR Part 312.

Report reviewed by: HENRY.MICHAEL.L.1058591684 Digitally signed by HENRY.MICHAEL.L.1058591684 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=HENRY.MICHAEL.L.1058591684 Date: 2013.06.10 10:59:51 -05'00'

Michael Henry, CHMM
Industrial Hygienist
CEMVS- EC-EQ

Report approved by: SLATTERY.KEVIN.P.1239587417 Digitally signed by SLATTERY.KEVIN.P.1239587417 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=SLATTERY.KEVIN.P.1239587417 Date: 2014.06.04 14:22:06 -05'00'

Kevin Slattery
Section Chief
CEMVS- EC-EQ

FIGURES

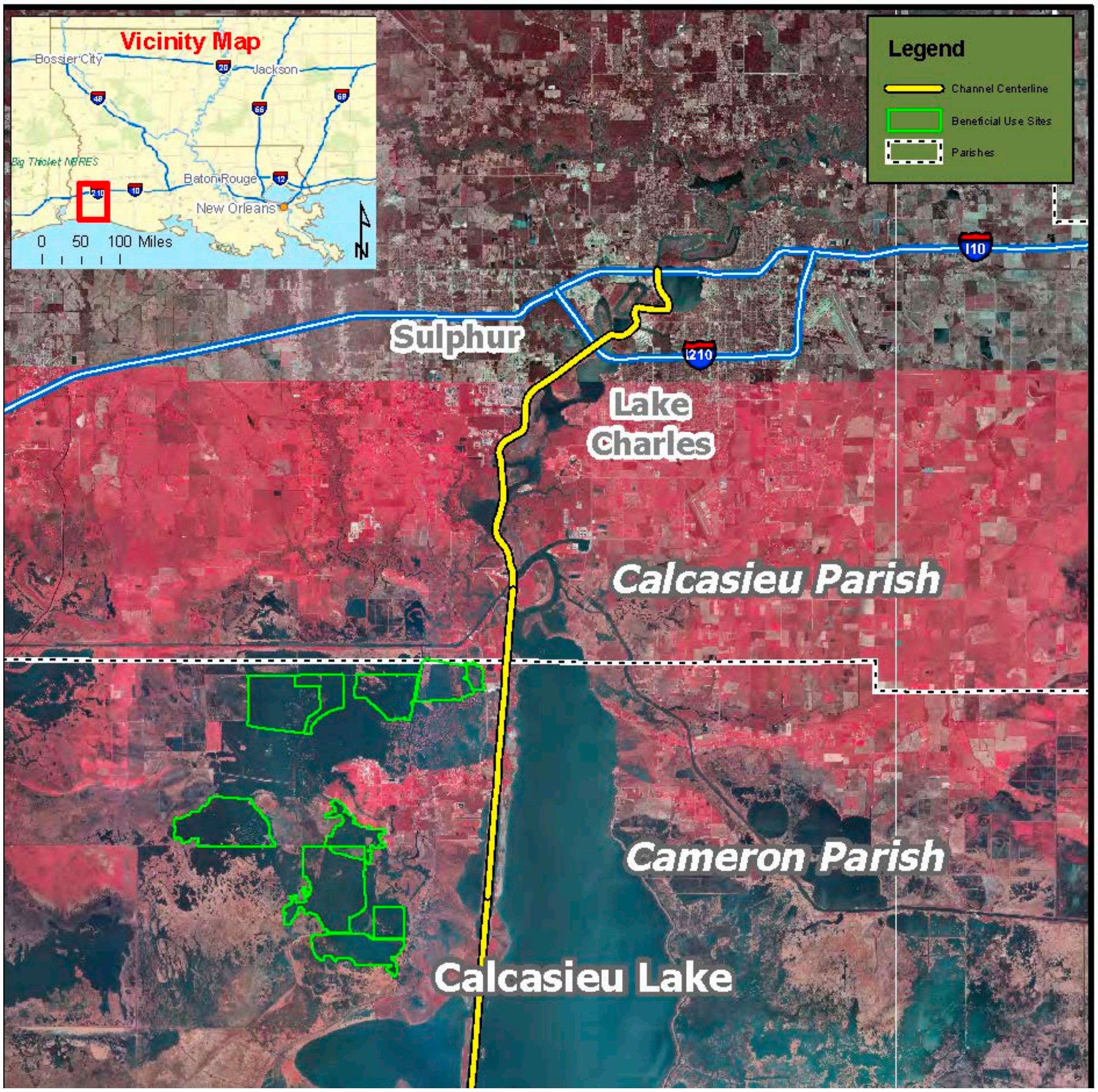

Figure 1 - Project vicinity map

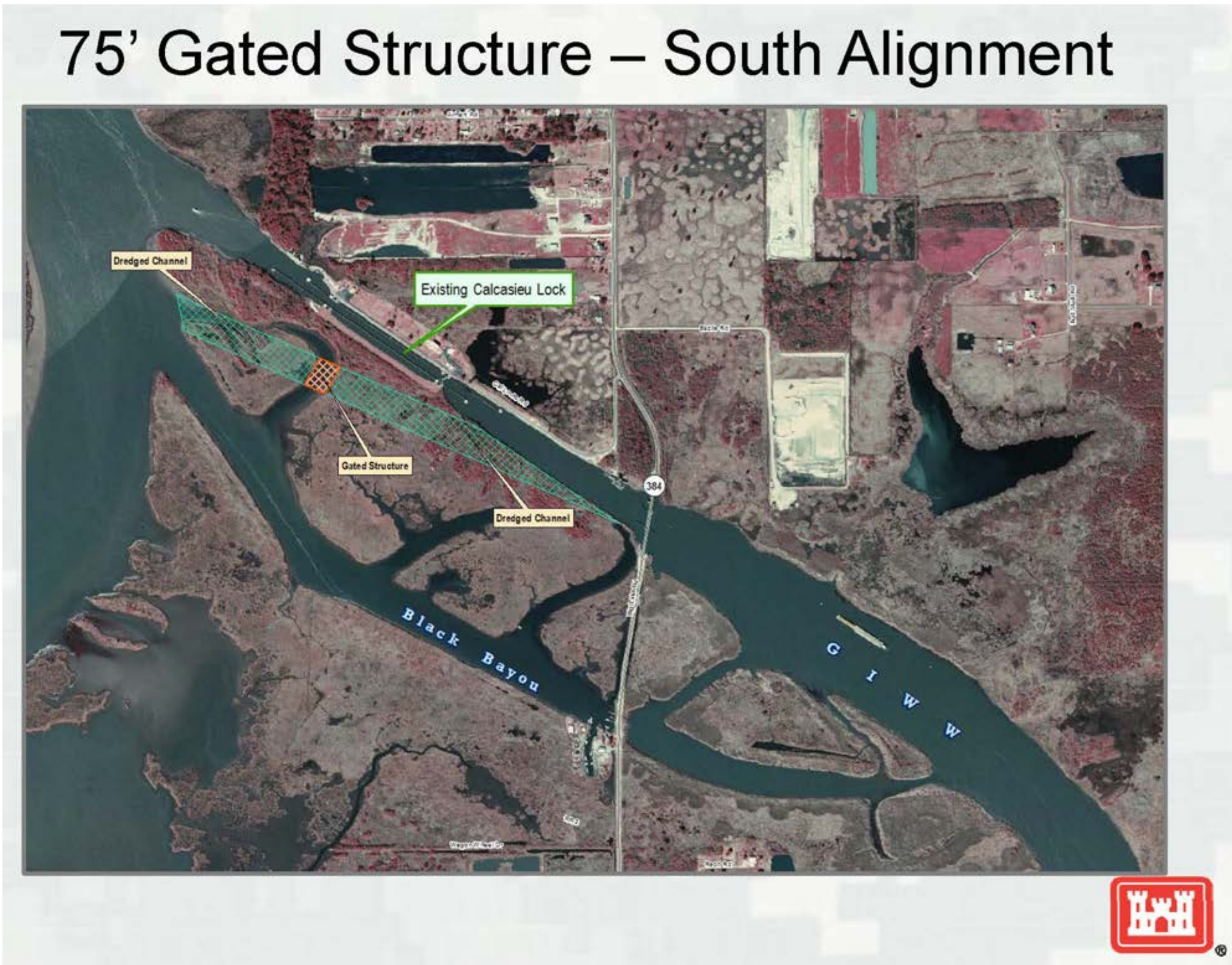

Figure 2.1 -- Gated structure alternative

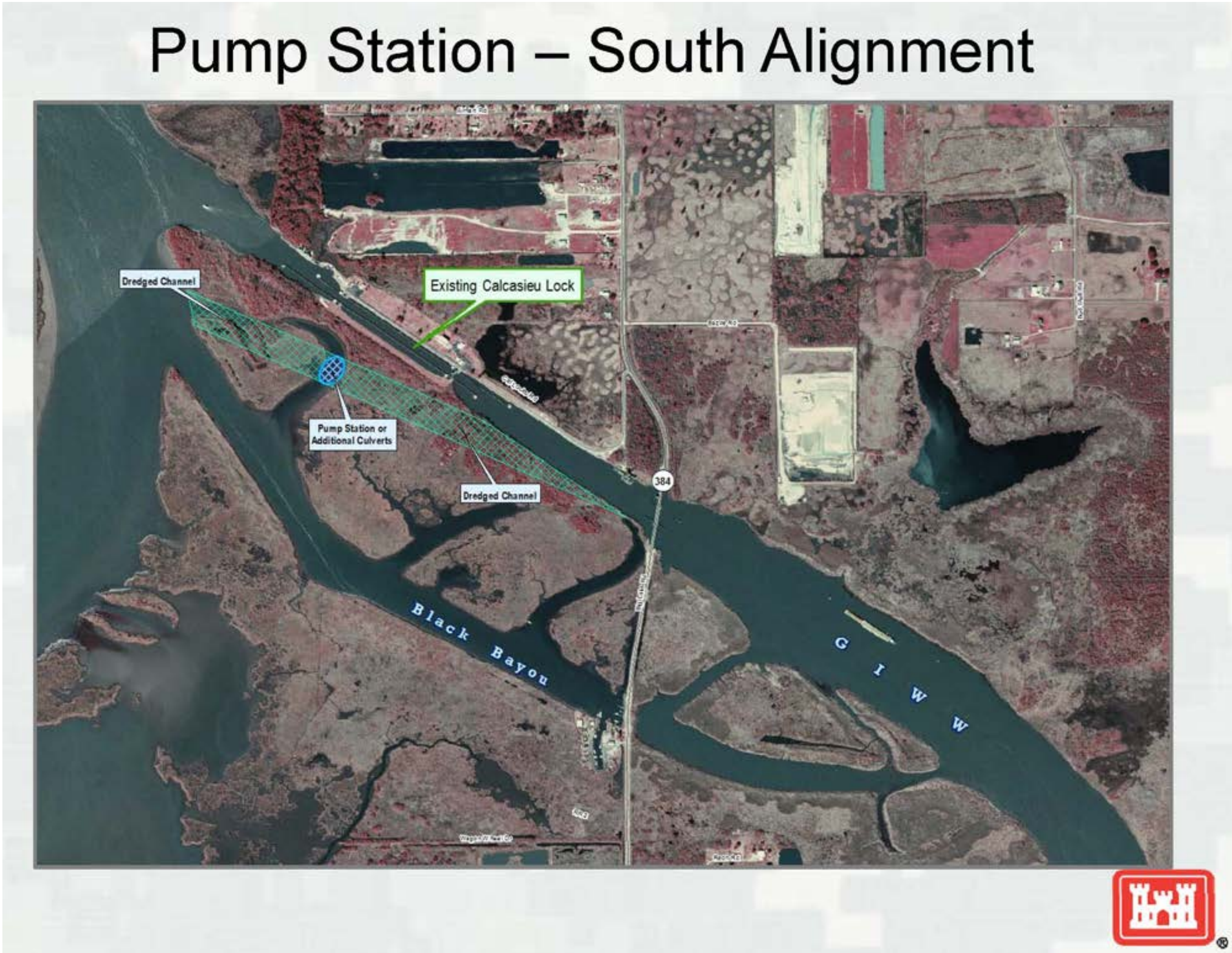

Figure 2.2 -- Pump station alternative

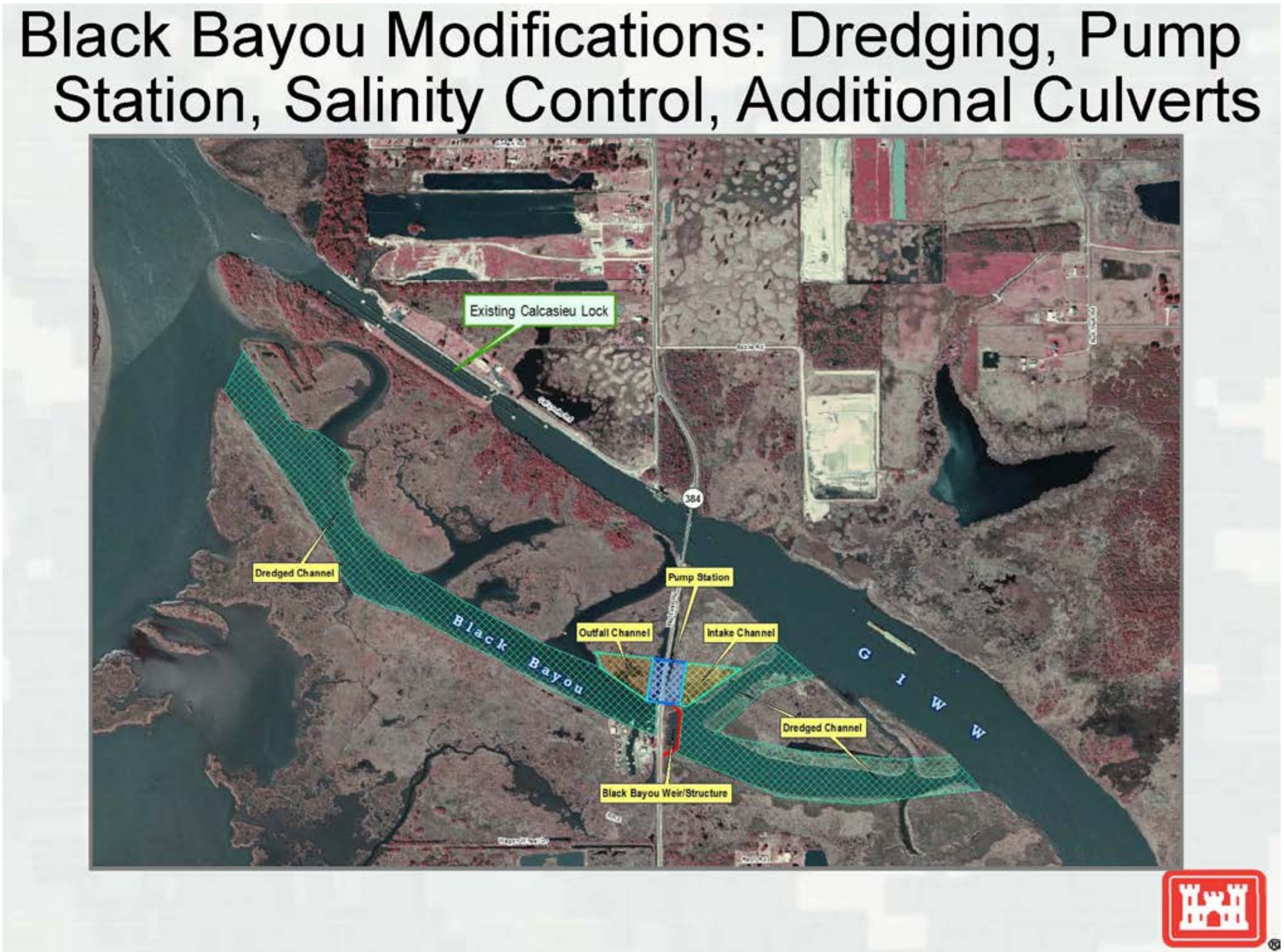

Figure 2.3 -- Black Bayou modifications alternative

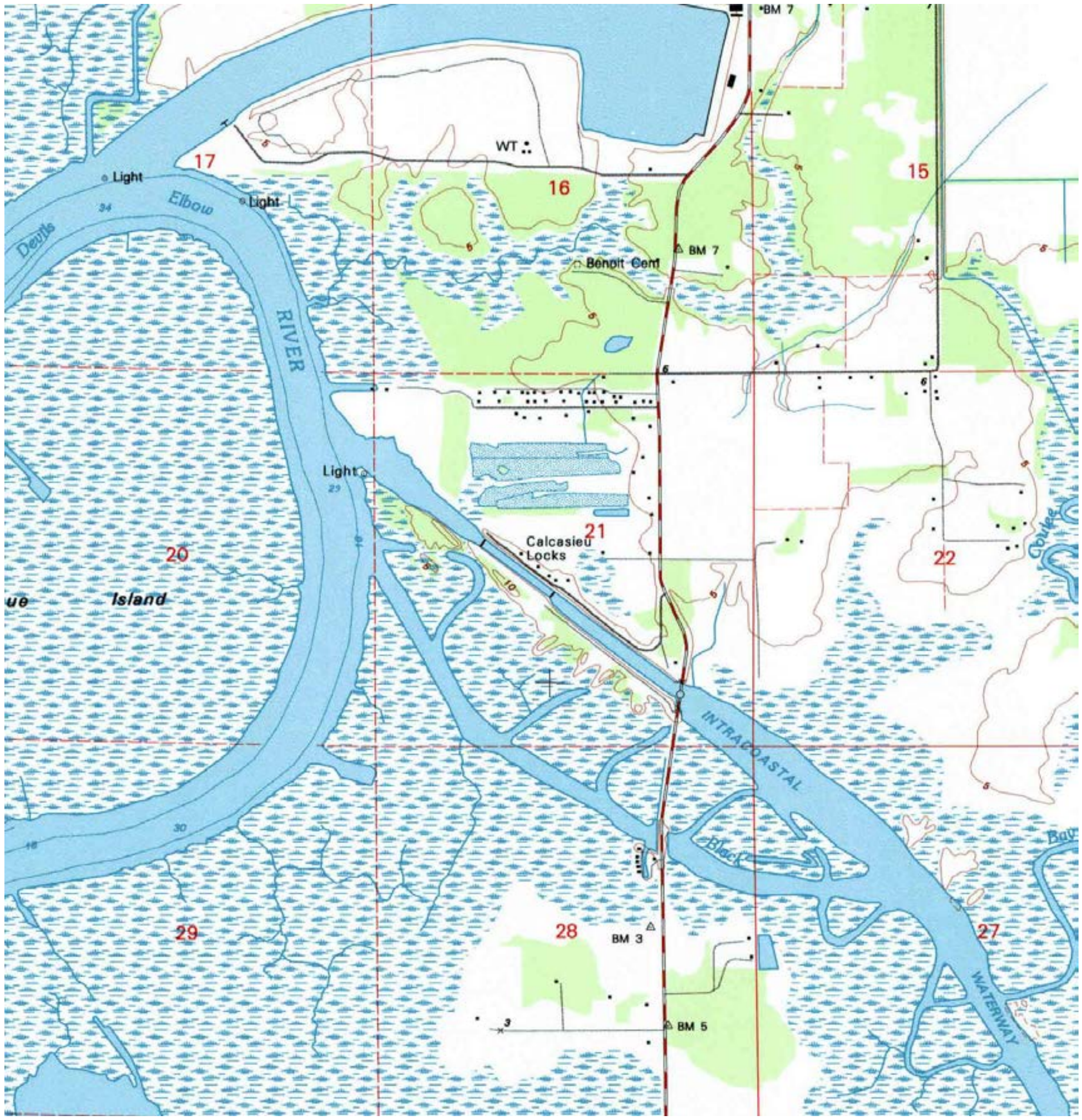

Figure 3 -- Site topographic map

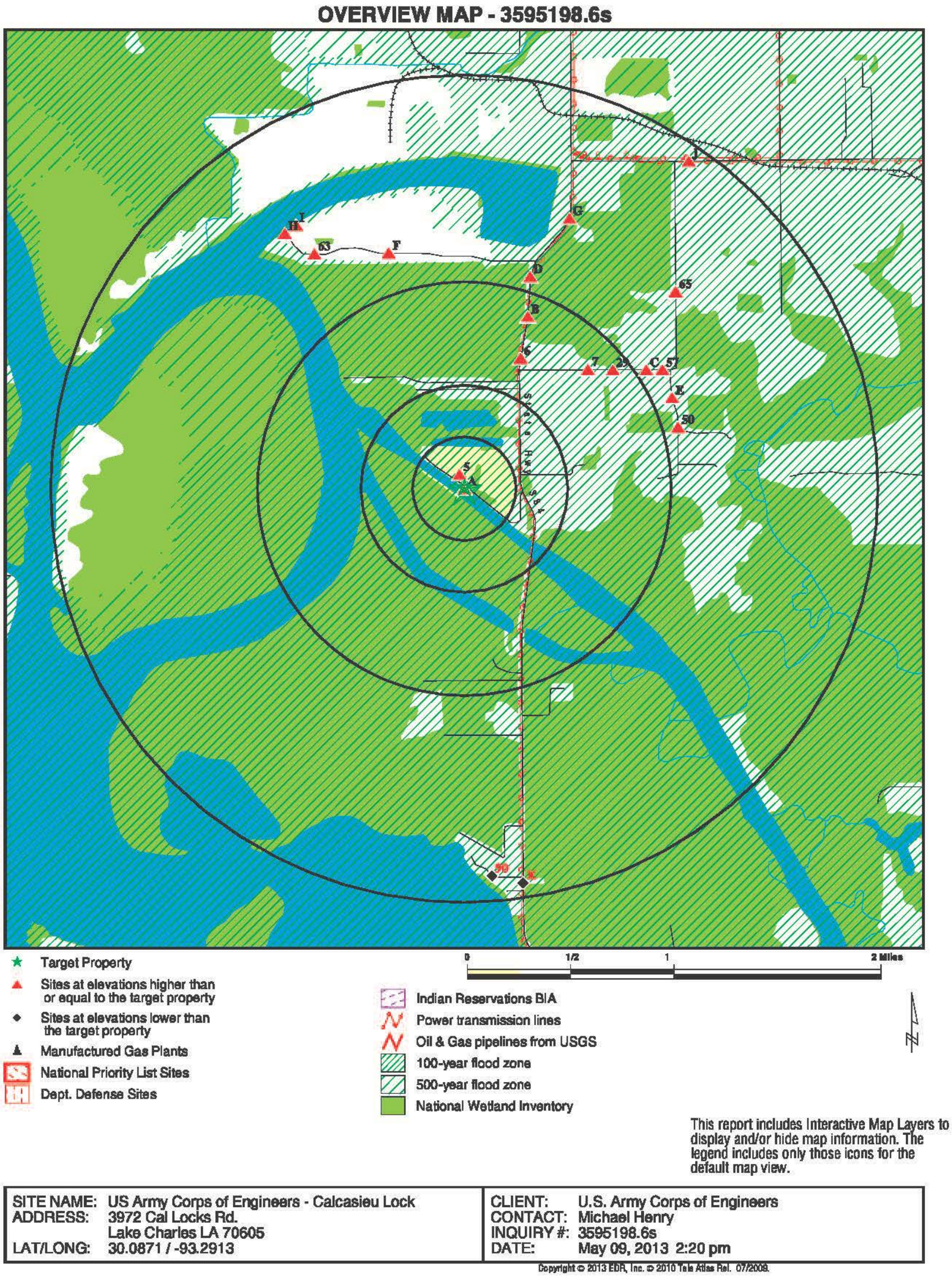

Figure 4 -- EDR radius map

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX N

ESSENTIAL FISH HABITAT ASSESSMENT

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX N

ESSENTIAL FISH HABITAT ASSESSMENT

FIGURES

TABLES

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX N

ESSENTIAL FISH HABITAT ASSESSMENT

I. INTRODUCTION

The Magnuson-Stevens Fishery Conservation and Management Act, as amended, PL 104-297, addresses the authorized responsibilities for the protection of Essential Fish Habitat (EFH) by National Marine Fishery Service (NMFS) in association with regional Fishery Management Councils. The act establishes eight regional Fishery Management Councils responsible for the protection of marine fisheries within their respective jurisdictions. *Essential Fish Habitat* is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." This definition extends to habitat specific to an individual species or group of species; whichever is appropriate, within each Fishery Management Plan (FMP). The act also authorizes the designation of Habitat Areas of Particular Concern (HAPC) for marine fisheries. These areas are subsets of EFH that are rare, susceptible to human degradation, ecologically important or located in an ecologically stressed area. Any Federal agency that proposes any action that potentially affects or disturbs any EFH must consult with the Secretary of Commerce and Fishery Management Council authority per the Magnuson-Stevens Act, as amended (2005). Interim final rules were published on December 19, 1997, in the Federal Register (Vol. 62. No. 244) to establish guidelines for the identification and description of EFH in fishery management plans. These guidelines include impacts from fishing and non-fishing activities as well as the identification of actions needed to conserve and enhance EFH. The rule was established to provide protection, conservation, and enhancement of EFH.

Per 50 CFR 600.920(e)(3), all EFH assessments must include the following information:

1. Description of the action;
2. Analysis of the potential adverse effects of the action on EFH and the managed species;
3. Federal agency's conclusions regarding the effects of the action on EFH; and
4. Proposed mitigation, if applicable

II. DESCRIPTION OF THE PROPOSED ACTION

A. Project Location. The study area is located in the north-central portion of the Calcasieu Estuary, in south-central Calcasieu Parish, Louisiana (figure N-1). There are two main types of aquatic habitat in the proposed project area. Coastal marsh, the predominant type, is represented by brackish marsh to the west of Louisiana Highway 384 (Big Lake Rd), and intermediate marsh to the east of this road. The marshes consist of emergent vegetation interspersed with and bordered by shallow open water. Deeper areas of open water distinct from marsh are represented by the GIWW, Black Bayou, and smaller contiguous water bodies.

Figure N-1. Calcasieu Lock Study Area

B. Description of the Viable Alternatives. A complete description of each of the proposed alternatives can be found in Section 5.6, *Final Array of Alternatives*, of the Main Report for the Calcasieu Lock, Louisiana, Feasibility Study. The final array of alternatives carried forward for consideration includes Alternatives 1 through 5. Alternative 1 has been chosen as the Recommended Plan. In terms of impacts to natural resources, Alternatives 1&2 are very similar to one another, as are Alternatives 3-5 to one another. This discussion of potential effects to EFH will be based on these two groupings of alternatives.

The main feature of Alternatives 1&2 is a new channel to carry freshwater flows from the Mermentau Basin around the south side of the existing Calcasieu Lock. This channel, constructed by hydraulic dredging, would be about 3,600 feet long and 300 feet wide at the surface. The channel would be dredged to -12 MLG, with a channel bottom width of 80 feet, and 1V on 3H side slopes. A 75-foot wide gated water control structure would be constructed inside the channel at about its midpoint to control the passage of freshwater flows. To control scouring, riprap would be placed in the channel for approximately 300 feet on either side of the water control structure at a thickness of 3 feet (approximately 17,200 tons) (figure N-2). Construction access to the site would be via barge. A permanent access road would be constructed from the lock to the culvert structure for use by the lock personnel.

Alternatives 3-5 involve adding either Supplemental Culverts to the Black Bayou Natural Resources Conservation Service (NRCS) structure to increase its capacity and operate in conjunctions with it, or a pump station. A weir would be constructed immediately east of the NRCS structure and would maintain the water elevation on the GIWW to the minimum 2.0 Mean Low Gulf (MLG). Black Bayou Dredging to the east and west of the NRCS structure would also occur (figure N-3).

The potential for all project alternatives to adversely affect habitats was assessed by an interagency Habitat Evaluation Team (HET). The HET was represented by federal and state natural resource agencies expressing interest in participating in the habitat evaluation, and for this project included the U.S. Fish and Wildlife Service, the NMFS, the NRCS, and the Corps.

With regard to the project alternatives as a whole, there would be unavoidable impacts to aquatic habitat including brackish marsh that was considered by the HET to be permanent. For each alternative, these marsh impacts would be offset by the disposal of dredged material into shallow water areas to restore and create marsh, such that no compensatory mitigation would be required to offset such losses. In contrast, potential impacts to deeper open water habitats like Black Bayou were not regarded as permanent by the HET. Appendix I, *Mitigation Plan*, provides a description of the mitigation plan developed for compensating for forested spoil bank habitat losses associated with Alternatives 1&2.

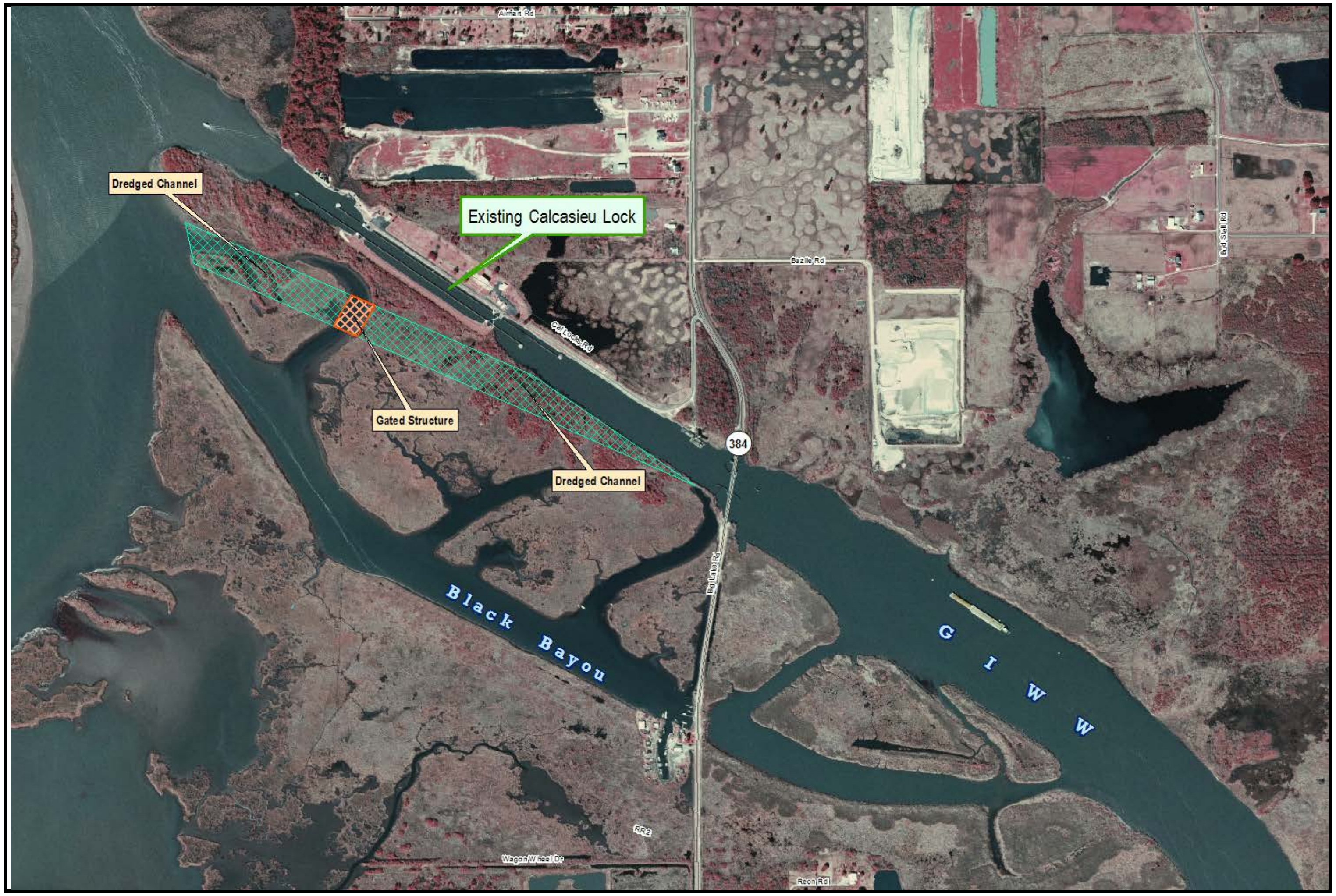

Figure N-2. Alternatives 1&2 General Location

Figure N-3. Alternatives 3-5 General Location

III. ESSENTIAL FISH HABITAT AND MANAGED SPECIES IN THE PROJECT AREA

A. Types of Essential Fish Habitat in the Gulf of Mexico. The project area is located within the jurisdiction of the Gulf of Mexico Fishery Management Council (GMFMC) with representatives from Texas, Louisiana, Florida, Alabama, and Mississippi. The GMFMC has identified and described EFH for hundreds of species covered by six FMPs. The Council prepares fishery management plans designed to manage fishery resources from where state waters end out to the 200-mile limit of the Gulf of Mexico. These waters are also known as the Exclusive Economic Zone.

The GMFMC has identified several types of EFH that occur in estuarine and marine conditions for the entire region of jurisdiction and for the state of Louisiana. These EFH types and their corresponding categories can be found in table N-1.

Table N-1. Essential Fish Habitat and Habitat Areas of Particular Concern Identified for Management by the Gulf of Mexico Fishery Management Council

Essential Fish Habitat		HAPC
Estuarine Areas	**Marine Areas**	**Texas/Louisiana**
Estuarine emergent wetlands	Water column	Flower Garden Banks Nat'l Marine Sanctuary
Mangrove wetlands	Vegetated bottoms	
Submerged aquatic vegetation	Non-vegetated bottoms	
Algal flats	Live bottoms	
Mud, sand, shell, & rock substrates	Coral reefs	
Estuarine water column	Artificial reefs	
	Geologic features	
	West Florida Shelf	
	Mississippi/Alabama Shelf	
	Louisiana/Texas Shelf	
	South Texas Shelf	

Source: NMFS, 2013

The only noted HAPC, Flower Garden Banks National Marine Sanctuary, is actually the northernmost coral reefs in the United States. Located approximately 105 miles directly south of the Texas/Louisiana border, the Flower Gardens are perched atop two salt domes rising above the sea floor. This bank supports a coral/sponge habitat and rich assemblages of associated animals and plants where the siltstone bedrock can still be seen in many places. This noted HAPC for Louisiana is not within the project vicinity.

B. Types of Essential Fish Habitat in the Proposed Project Area. The estuarine waters of Calcasieu Parish are included in the EFH managed area. Essential Fish Habitat located within the proposed project area includes:

Estuarine Marsh. Of the four main types of emergent marsh (saline, brackish, intermediate, and freshwater), only brackish is currently present within the proposed project area. Brackish marsh is made up of wiregrass (*Spartina patens*), threecorner grass (*Scirpus olneyi*) and coco (*Scirpus robustus*).

Marsh-Water Interface (Marsh-edge). Marsh edge habitats serve as the defining border between the emergent marsh vegetation and open water and have been referred to as 'critical transition zones' that promote the movement of organisms and nutrients between intertidal and subtidal estuarine environments (Levin et al. 2001). These habitats serve as productive nursery areas for juvenile finfishes and decapod crustaceans of economic importance and provide productive feeding grounds for resident and transient predators (Birdsong 2002).

Mud/Sand/Shell/Rock Substrates. This habitat is comprised of unconsolidated mud, sand, shell, and/or rock substrates; which may support a large population of infaunal organisms as well as a variety of transient planktonic and pelagic organisms.

Estuarine Water Column. The estuarine water column includes the open waters of Calcasieu Lake, which are generally shallow with over half between 0 and 6 feet in depth.

Intermediate marsh, marsh-water interface, mud/sand/shell substrates, and estuarine water column located to the east of Calcasieu Lock and Louisiana Highway 384 are not considered to be EFH because these areas are not accessible by the managed species discussed below.

C. Gulf of Mexico Fishery Management Council Managed Species with Designated Essential Fish Habitat in the Proposed Project Area

Numerous publications and websites, with assistance from the Habitat Conservation Division of the NMFS Southeast Regional Office, Gulf Branch, were used to identify managed species and EFH for life cycle stages of these species within the proposed project area in Calcasieu Lake estuary (GMFMC 2004, 2005, 2012).

Essential Fish Habitat was identified for certain life stages of brown shrimp (*Farfantepenaeus aztecus*), white shrimp (*Litopenaeus setiferus*), and red drum (*Sciaenops ocellatus*). Table N-2 summarizes species managed under the Magnuson-Stevens Fishery Conservation and Management Act grouped by FMP for which EFH designations exist in the proposed project area.

Table N-3 provides monthly relative abundance codes for managed species life stages in Calcasieu Lake estuary.

Brown shrimp juveniles were categorized as common to highly abundant year round. Larvae were categorized as common to abundant between February and November and as rare in December and January.

White shrimp juveniles were categorized as common to abundant year round. Larvae were considered rare to abundant between May and November and as rare to not present between December and April.

Red drum adults are classified as rare to common between April and November, and as rare between December and March. Juveniles were classified as common throughout the year, except in areas with salinity ranging from 0-0.5, where they are classified as rare. Red drum larvae in Calcasieu Lake estuary was classified as rare to common between August and March, and not present between April and July.

Table N-2. Essential Fish Habitat Requirements for Species Managed by the Gulf of Mexico Fishery Management Council: Ecoregion 4, Mississippi River Delta (South Pass) to Freeport, TX

Species	Life Stage	Zone	EFH
Brown Shrimp	Larvae/Postlarvae	Marine/Estuarine	<82 m; planktonic; sand/shell/soft bottom, SAV, emergent marsh, oyster reef
	Juveniles	Estuarine	<18 m; SAV, sand/shell/soft bottom, emergent marsh, oyster reef
White Shrimp	Larvae/Postlarvae	Marine/Estuarine	<82 m; planktonic; soft bottom, emergent marsh
	Juveniles	Estuarine	<30 m; soft bottom, emergent marsh
Red Drum	Larvae/Postlarvae	Estuarine	all estuaries; planktonic; SAV, sand/shell/soft bottom, emergent marsh
	Juveniles	Estuarine/Marine	GOM <5 m; Vermilion Bay & E all estuaries SAV, sand/shell/soft/hard bottom, emergent marsh
	Adults	Estuarine/Marine	GOM 1-46 m; Vermilion Bay & E all estuaries; pelagic; SAV, sand/shell/soft/hard bottom, emergent marsh

Source: NMFS, 2013

Table N-3. Average Monthly Relative Abundance Codes [1] for Management Species Life Stages in Calcasieu Lake Estuary Over All Salinity Values [2]

Managed Species	Life Stage	Salinity (ppt)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Brown Shrimp	Juveniles	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	3	3	4	5	5	4	4	4	4	3	3	3
		5-15	3	3	4	5	5	4	4	4	4	3	3	3
		0.5-5	3	3	4	5	5	4	4	4	4	3	3	3
		0-0.5	3	3	4	5	5	3	3	3	3	3	3	3
	Larvae	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	-	-	-	4	4	3	3	3	3	3	3	2
		5-15	2	4	4	4	4	3	3	3	3	3	3	2
		0.5-5	2	3	3	3	3	3	3	3	3	3	3	2
		0-0.5	0	0	0	0	0	0	0	0	0	0	0	0
White Shrimp	Juveniles	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	3	3	3	3	3	3	4	4	4	4	4	3
		5-15	3	3	3	3	3	3	4	4	4	4	4	3
		0.5-5	3	3	3	3	3	3	4	4	4	4	4	3
		0-0.5	3	3	3	3	3	3	3	3	3	3	3	3
	Larvae	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	-	-	-	2	3	4	4	3	4	4	3	2
		5-15	0	0	0	2	3	4	4	3	4	4	3	2
		0.5-5	0	0	0	0	2	3	3	3	3	3	3	2
		0-0.5	0	0	0	0	0	0	0	0	0	0	0	0
Red Drum	Adults	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	2	2	2	3	3	3	3	3	3	3	3	2
		5-15	2	2	2	3	3	2	2	2	3	3	3	2
		0.5-5	2	2	2	3	3	2	2	2	3	3	3	2
		0-0.5	0	0	0	2	2	2	2	2	2	2	2	0
	Juveniles	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	3	3	3	3	3	3	3	3	3	3	3	3
		5-15	3	3	3	3	3	3	3	3	3	3	3	3
		0.5-5	3	3	3	3	3	3	3	3	3	3	3	3
		0-0.5	2	2	2	2	2	2	2	2	2	2	2	2
	Larvae	> 25	-	-	-	-	-	-	-	-	-	-	-	-
		15-25	-	-	-	0	0	0	0	2	3	3	3	3
		5-15	2	2	2	0	0	0	0	2	2	2	2	2
		0.5-5	2	2	2	0	0	0	0	2	2	2	2	2
		0-0.5	0	0	0	0	0	0	0	0	0	0	0	0

[1] 5 - Highly Abundant, 4 - Abundant, 3 - Common, 2 - Rare, 0 - Not Present
[2] The values for these codes were obtained from "The Estuarine Living Marine Resources" database (http://www8.nos.noaa.gov/biogeo_public/elmr.aspx).

IV. THE EFFECTS OF THE PROPOSED ACTION ON EFH AND MANAGED SPECIES

As defined by the Magnuson-Stevens Act (50 CFR 600.810), "Adverse Effect" includes any impact which reduces the quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions.

A. Effects on EFH. For Alternatives 1&2, about 9.7 acres of emergent brackish marsh and 4.3 acres of open water would be directly impacted by constructible elements, based on geographic information system analysis. The emergent brackish marsh would be converted into open water (new channel) or an area occupied by the sluice gate (table N-4). Approximately 233,000 cubic yards (yd^3) of hydraulically dredged material would be obtained during construction of the new channel.

For Alternatives 3-5, approximately 4.9 acres of emergent brackish marsh and 51.4 acres of open water would be directly impacted by constructible elements (table N-4). Approximately 53,000 yd^3 of hydraulically dredged material would be obtained during construction.

Table N-4. Pre- and Post-Construction Habitat Types (acre) by Feature
for Alternatives 1&2 and Alternatives 3-5 (Excluding Placement of Dredged Material)

Habitat Type	Pre-Construction	Post-Construction
Alternatives 1&2		
Forested Spoil Bank	11.5	
Dredged Channel		11.5
Emergent Brackish Marsh	9.7	
Dredged Channel		9.7
Open Water Brackish Marsh	4.3	
Dredged Channel		3.3
Pump Station or Culverts		1.0
TOTAL	**25.4**	**25.4**
Alternative 3		
Developed	0.5	
Pump Station		0.5
Emergent Brackish Marsh	4.9	
Dredged Channel		2.0
Pump Outfall Channel		2.4
Pump Station		0.5
Open-Water Brackish Marsh	51.0	
Dredged Channel		49.4
Pump Outfall Channel		1.0
Pump Station		0.7
Open Water	0.4	
Dredged Channel		0.4
TOTAL	**56.8**	**56.9**

The dredged material would be placed in areas of nearby open water and surrounded by containment dikes, resulting in the conversion of open water to emergent marsh. The proposed placement sites are illustrated in figure N-4. Using an estimate of 4,800 yd^3 of fill per acre (assuming the existing substrate elevation of these placement locations is -2.0 MLG and they would be filled to +1.5), Alternatives 1&2 would result in approximately 50 acres of converted emergent marsh habitat; for Alternatives 3-5, disposal was assumed to occur at the same locations, but would likely result in fewer acres of emergent marsh habitat because of the smaller amount of dredged material.

B. Effects on Managed Species. The proposed work is anticipated to occur during 2016-2017, with project completion by 2018. It is presumed that once construction has commenced, work would occur throughout the year, and not on a seasonal basis, to the extent practicable. Construction activities would be subject to seasonal restrictions if any Bald Eagle nest or nesting area of the Brown Pelican or other colonial waterbirds were to become established in the project area (see Appendix A, *Biological Assessment*). At least two life stages of brown shrimp, white shrimp, and red drum have the potential to be present within the Calcasieu Lake estuary throughout the year (table N-3).

Brown and White Shrimp (juveniles, larvae). Shrimp species include the brown shrimp (Farfantepenaeus *aztecus*), and white shrimp (*Litopenaeus setiferus*). Adult shrimp generally occupy offshore areas of higher salinity, where spawning occurs. After hatching, larvae enter estuaries and remain there throughout the juvenile stage. Estuarine habitat serves as a nursery area for shrimp, offering a suitable substrate, an abundant food supply, and protection from predators. Sub-adult shrimp consume organic matter, including marsh grasses and microorganisms, found in estuarine sediments. Adult shrimp are omnivorous. Essential Fish Habitat for shrimp is identified in table N-2.

Red Drum (adults, juveniles, larvae). Red drum (*Scianeops ocellatus*) is an important commercial and recreational gamefish found in coastal waters throughout the Gulf of Mexico. Adults inhabit nearshore waters, particularly areas within the surf zone or in the vicinity of inlets. Spawning occurs in nearshore areas, and eggs and larvae are transported by tides and wind currents into estuaries. Larvae and juveniles occupy estuarine environments until maturation. Red drum are predatory in all stages of life; however, the type of prey consumed varies with life stage. Sub-adult red drum primarily consume small marine invertebrates including mysids and copepods, while adult specimens feed on large marine invertebrates, including shrimp and crabs, and small fishes. Essential Fish Habitat for red drum is identified in table N-2.

C. Conclusion. Dredging and other construction activities would adversely impact EFH used by red drum and shrimp. There is a potential for the construction activities to impact red drum and/or shrimp larvae in the proposed areas of disturbance. However, based on the relative abundance of red drum larvae in the area during this life stage (table N-3), the probability of encounter is very low. Since adult and juvenile red drum and shrimp are mobile, it is expected that they would avoid the areas of disturbance and therefore will not be impacted. The dredging of emergent marsh and open water areas would also result in the temporary loss of benthic organisms (prey species) in the vicinity of the construction. However, they would recolonize available habitat within a relatively short time period. More mobile prey species would be expected to avoid the areas of disturbance and therefore would not be impacted.

Based upon the project design and the impacts associated with the dredging and other construction, the Corps believes the proposed project ***may adversely affect EFH***. Therefore, the Corps has coordinated with NMFS to determine whether for Alternative 1 (Recommended Plan) the 50 acres of dredged material placement in open water to create marsh are sufficient to compensate for EFH impacts.

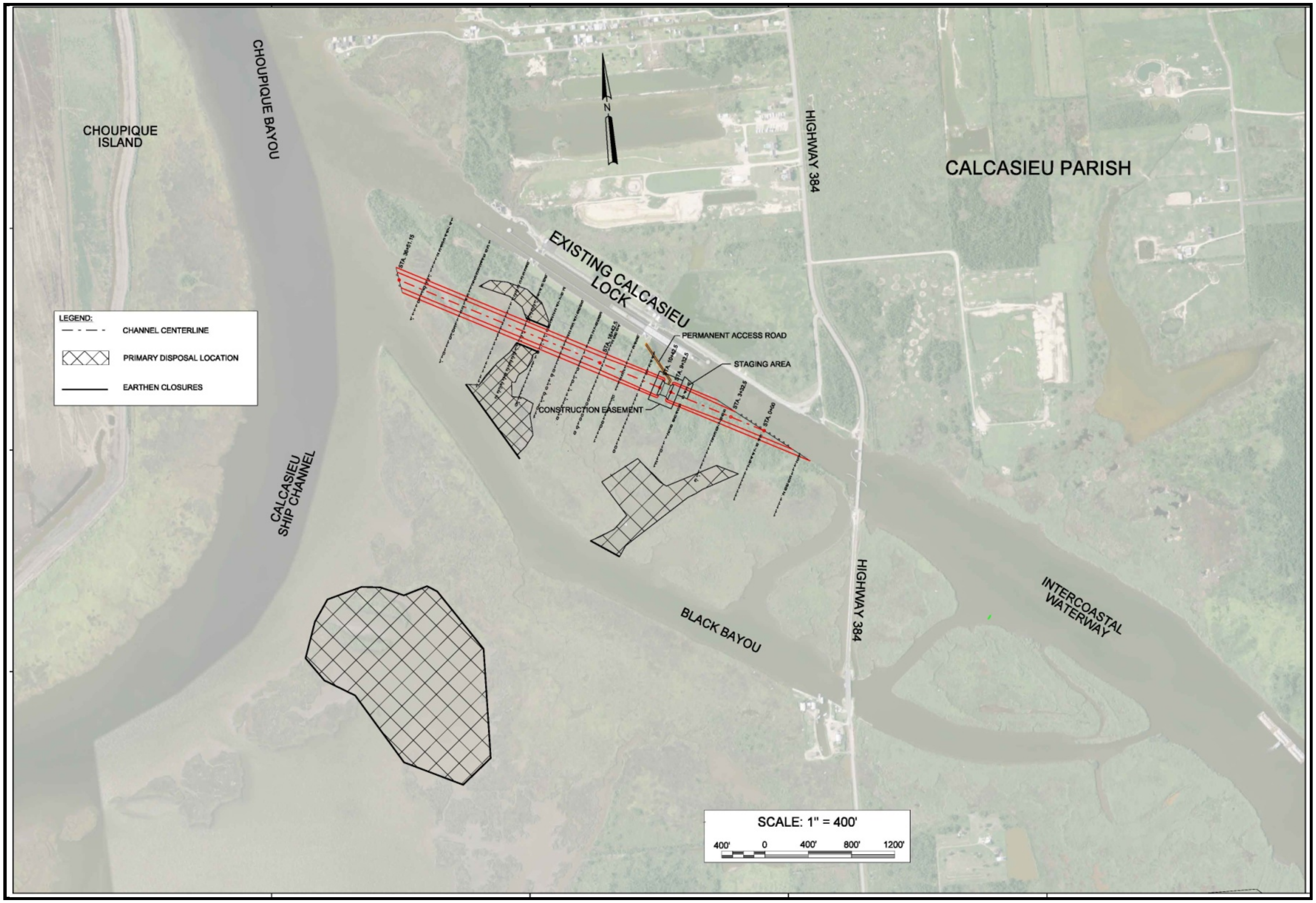

Figure N-4. Alternative 1 (Recommended Plan) and Dredged Material Disposal Sites

V. REFERENCES

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CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX O

CUMULATIVE IMPACTS

CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

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APPENDIX O

CUMULATIVE IMPACTS

I. INTRODUCTION

Section 1508.8 of Title 40 of the Code of Federal Regulations, promulgated by the President's Council on Environmental Quality to implement the National Environmental Policy Act, defines cumulative impact as:

> *…the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions." Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.*

In assessing cumulative impact, consideration is given to

1. the degree to which the proposed action affects public health or safety,
2. unique characteristics of the geographic area,
3. the degree to which the effects on the quality of the human environment are likely to be highly controversial,
4. the degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks, and
5. whether the action is related to other actions with individually insignificant but cumulatively significant impacts on the environment.

Cumulative effects can result from many different activities, including the addition of materials to the environment from multiple sources, repeated removal of materials or organisms from the environment, and repeated environmental changes over large areas and long periods. Complicated cumulative effects occur when stresses of different types combine to produce a single effect or suite of effects. Large, contiguous habitats can be fragmented, making it difficult for organisms to locate and maintain populations in disjunct habitat fragments. Cumulative impacts may also occur when the timing of perturbations are so close in space that their effects overlap.

II. GEOGRAPHIC BOUNDARIES OF THE CALCASIEU-SABINE BASIN

Although the project area is limited to the Calcasieu Lock and vicinity, cumulative impacts involve the broader coastal basin. For that reason, most of the information in this cumulative impacts analysis applies to the Calcasieu-Sabine Basin in Louisiana's Chenier Plain. The information used in this report has been gathered from published sources and government documents.

The Calcasieu-Sabine Basin is the westernmost coastal basin in Louisiana's Chenier Plain. Composed of the Calcasieu-Sabine and Mermentau hydrologic basins, the Chenier Plain was formed 3,000 to 4,000 years ago during periods when the Mississippi River followed a westerly course [Louisiana Coastal Wetlands Conservation and Restoration Task Force, (LCWCRTF) 2002]. The sediments were reworked by marine forces into low ridges and intervening wetland swales parallel to the coastline. These ridges, which consisted mainly of sand and shell, were typically higher in elevation than surrounding marshes and were colonized by live oaks. The Chenier Plain extends from the western bank of the Freshwater Bayou Canal westward to the Sabine River on the Louisiana-Texas border, and from the marsh area north of the Gulf Intracoastal Waterway (GIWW) south to the Gulf of Mexico in Vermilion, Cameron, and Calcasieu Parishes (figure O-1).

The Calcasieu-Sabine Basin consists of approximately 630,000 acres, 50 percent of which is classified as marsh. The northern boundary of the basin is defined by the GIWW. The eastern boundary follows the eastern leg of State Highway 27; the western boundary is the Sabine River and Sabine Lake; and the southern boundary is the Gulf of Mexico (USGS, 2007).

The basin consists of two semi-distinct hydrologic units, the Calcasieu River Basin and the Sabine River Basin, which are continuous between Louisiana and Texas. The Calcasieu, Sabine, and Neches Rivers are the principal sources of freshwater inflow into this region. The Sabine and Calcasieu Rivers follow a north-south gradient, whereas the Neches River flows into Sabine Lake from the northwest. Additionally, an east-west flow occurs between the basins via the GIWW and existing canals on the Sabine National Wildlife Refuge(NWR) [U.S. Geological Survey (USGS), 2007).

Managed wetlands are a significant feature of the Calcasieu-Sabine Basin. Approximately 24 percent (148,600 acres) of the basin lands is publicly owned as Federal refuges (USGS, 2007).

III. TEMPORAL BOUNDARIES

The cumulative impacts on the Calcasieu-Sabine Basin began with the construction of navigation channels in the Calcasieu and Sabine Rivers in the early 1870s and 1880s, respectively. The channels were continuously deepened and widened for the next 100 years, causing saltwater intrusion coupled with significant marsh loss and vegetation change. More than 82 percent, over 100,000 acres, of documented marsh loss in the Calcasieu-Sabine Basin occurred between 1955 and 1974, the period in which the largest incremental changes were made to the navigation channels. Because the navigation channels would remain authorized until Congress determines otherwise, their status must be considered indefinite.

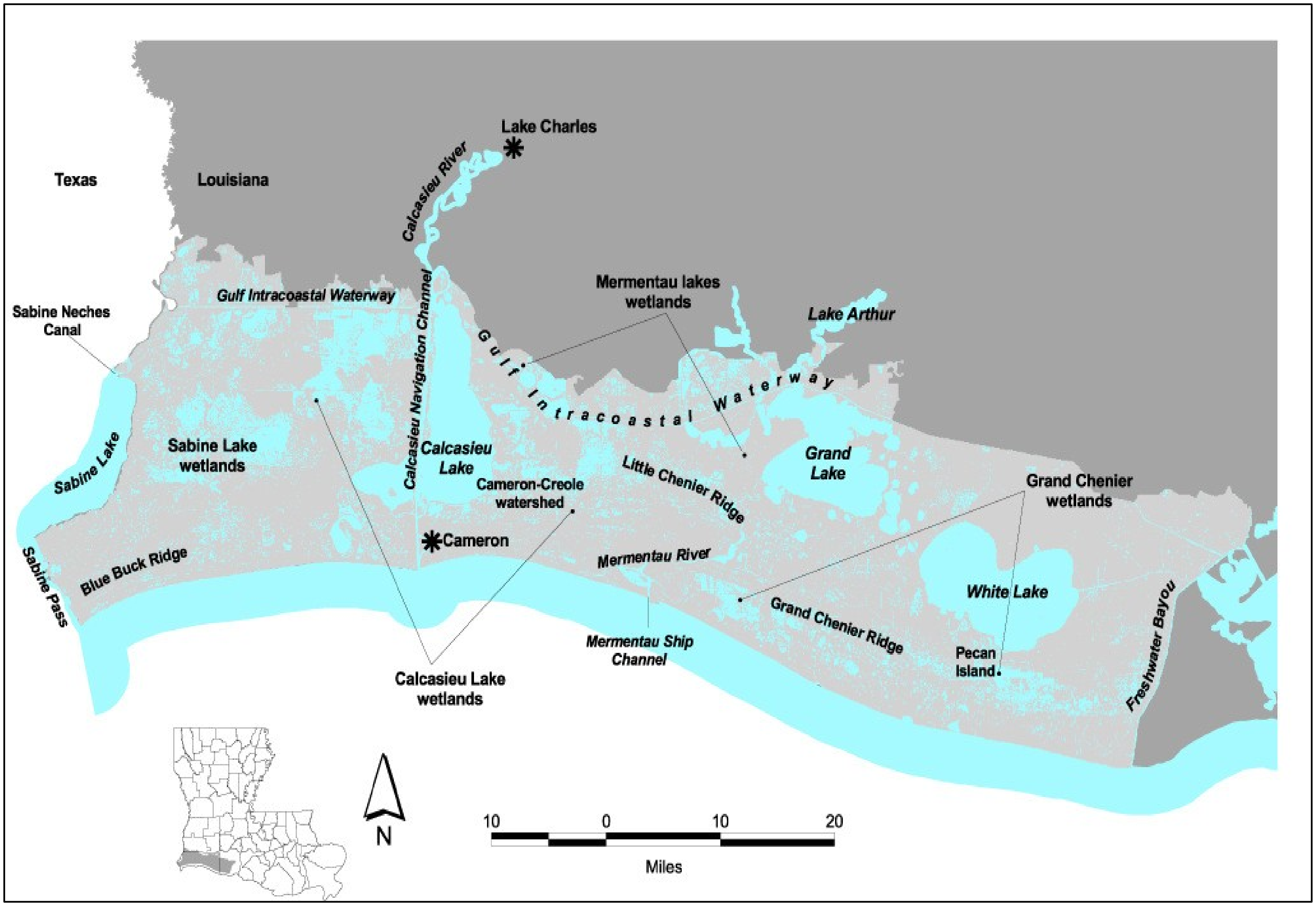

Figure O-1. Louisiana's Chenier Plain
(Source: CEMVN. 2004. Louisiana Coastal Area Ecosystem Restoration Study. Vol I: Main Report. Pages 2-16)

IV. NATURAL RESOURCES

This feasibility report/EIS includes considerations of the effects of creating a new freshwater bypass around Calcasieu Lock, and dredged material placement on natural resources of the area, including essential fish habitat, wetlands, and protected species. This cumulative impacts discussion focuses on the primary issue affecting these natural resources--land loss due to coastal subsidence and shoreline erosion, and plant community changes due to saltwater intrusion. The hydrologic alterations that have had the most significant impact on these resources are navigation corridors. The Calcasieu and Sabine-Neches navigation channels have been expanded incrementally to the extent that the existing channel cross-sections are more than 40 times larger than when the channels were first dredged in the late 1800s. These changes have affected hydrology by channeling saltwater into the historically low-salinity estuary. Secondary causes of landscape change include storms, petrochemical exploration, and herbivory.

A. Past Actions

1. Historical Landscape Change. Abundant evidence indicates that the Calcasieu-Sabine Basin was historically fresher than it is today. Both O'Neil (1949) and a 1951 Soil Conservation Service vegetation map of Cameron Parish show broad expanses of unbroken Jamaica swamp sawgrass (*Cladium mariscus*) marsh [U.S. Department of Agriculture (USDA), 1951, in LCWCRTF, 2002]. Sawgrass is found in fresh and intermediate marshes and tolerates salinities between 0 and 2 ppt (Penfound and Hathaway 1938). At the time of the 1951 survey, sawgrass marsh covered approximately 475 square-miles of Cameron Parish and was the dominant vegetative community.

Water from Calcasieu Lake was fresh enough to be used in the irrigation of rice fields in Cameron Parish around 1875-1910 (David Richard, Stream Companies, Inc., personal communication, in LCWCRTF, 2002). Water from Calcasieu Lake must have been essentially fresh during this period, because rice is adversely affected by water salinities that exceed 0.6 ppt (Hill, 2001). In the early 1900s, lower Calcasieu Lake was considered marginal habitat for oysters because of the frequency of freshwater and low-salinity events. Oysters, which cannot survive in fresh water, inhabit waters within the salinity range of 5-30 ppt (Galtsoff, 1964), are now found throughout much of the Calcasieu Lake bottom (USDA, 1994, in LCWCRTF, 2002). In contrast to these formerly fresh conditions in Calcasieu Lake, average salinities at five Cameron Prairie Refuge monitoring stations within Calcasieu Lake ranged from 8.01 to 11.66 ppt during 1994-95 (LCWCRTF, 2002).

A total of 116,791 acres of wetlands in the Calcasieu-Sabine Basin has converted to open water since 1932 (USGS, 2007). Biologists, ecologists, and natural resource managers who possess intimate knowledge of the historical events that shaped the ecosystem were interviewed by the LCWCRTF to determine specific causes of land changes in the basin. The scientists attribute virtually all of the habitat changes and land losses in the basin to a combination of human-induced hydrologic changes, sometimes accompanied by severe storm events. The hydrologic alteration that has had the most impact is the Calcasieu Ship Channel, a major avenue for saltwater and tidal intrusion, which has caused extremely severe marsh losses (LCWCRTF, 2002).

2. Hydrologic Modifications for Navigation. Freshwater inflow to the basin occurs primarily through the Calcasieu and Sabine Lakes via the Calcasieu and Sabine Rivers. Marshes within the basin historically drained into these two large lakes. This process was altered by the construction of channels to enhance navigation and mineral extraction activities. Navigation channels now dominate the hydrology of the basin.

a. Calcasieu River and Ship Channel. The lower Calcasieu River and the Calcasieu Ship Channel have been maintained for navigation since 1874, when the Corps first constructed a 5-foot-deep x 80-foot-wide x 7,500-foot-long navigation channel through the outer bar of Calcasieu Pass, between Calcasieu Lake and the Gulf of Mexico. Prior to the initial dredging of the Calcasieu Ship Channel, there was a 3.5-foot-deep shoal at the mouth of the Calcasieu River (War Department, 1897). This natural bar acted as a constriction, minimizing saltwater and tidal inflow into the basin. Removal of the channel mouth bar, coupled with subsequent widening, deepening, and lengthening of the ship channel, allowed increased saltwater and tidal intrusion into the estuary, resulting in catastrophic marsh loss, tidal export of vast quantities of organic marsh substrate, and an overall shift to more saline habitats in the region (USDA, 1994, in LCWCRTF, 2002). In addition, the ship channel permits the upriver flow of denser, more saline water as a saltwater wedge. Figure O-2 shows the historical channel dimensions of the Calcasieu Ship Channel.

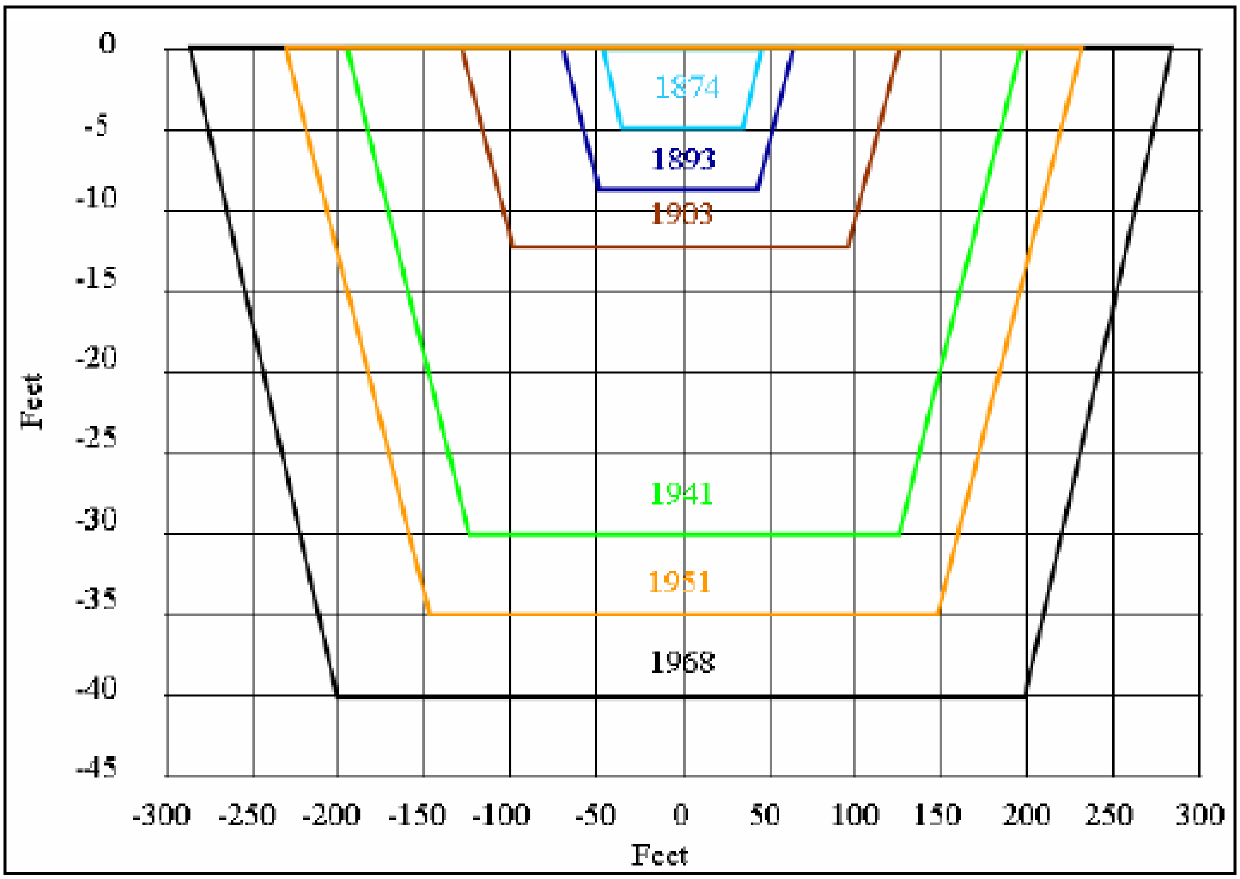

Figure O-2. Historical Channel Dimensions of the Calcasieu Ship Channel
(Source: LCWCRTF, 2002)

In 1968, the Corps completed construction of the Calcasieu River Saltwater Barrier on the Calcasieu River north of the City of Lake Charles. This barrier minimized the flow of the saltwater wedge into the upper reaches of the Calcasieu River to protect agricultural water supplies. The structure consists of navigation gates and a flood control barrier with five adjustable tainter gates.

b. Sabine River, Neches River, and Sabine Lake. The Sabine River is the dominant influence across most of the Calcasieu-Sabine Basin in moderating Gulf salinity and tidal fluctuations. Sabine Pass was first dredged for navigation in 1880. Prior to this, the River had an outer bar depth of 3.5 feet. In 1880, a channel 6 feet deep x 70-100 feet wide was dredged through the bar (War Department 1890). Over time, the channel was progressively deepened to its present depth of 40 feet. The Sabine-Neches Canal (later to become the Sabine-Neches Ship Channel) was constructed in the early 1900s, when the Corps dredged the channel along the west bank of Sabine Lake to a depth of 9 feet and a width of 100 feet. In 1914-1916, the channel was deepened to 25 feet and extended to Beaumont, Texas. This deepening led to the first reports of saltwater intrusion in the channel (Wilson 1981, in LCWCRTF, 2002). Since then, the channel has gradually been deepened and widened to its present dimensions of 40 feet deep and 400 feet wide (figure O-3).

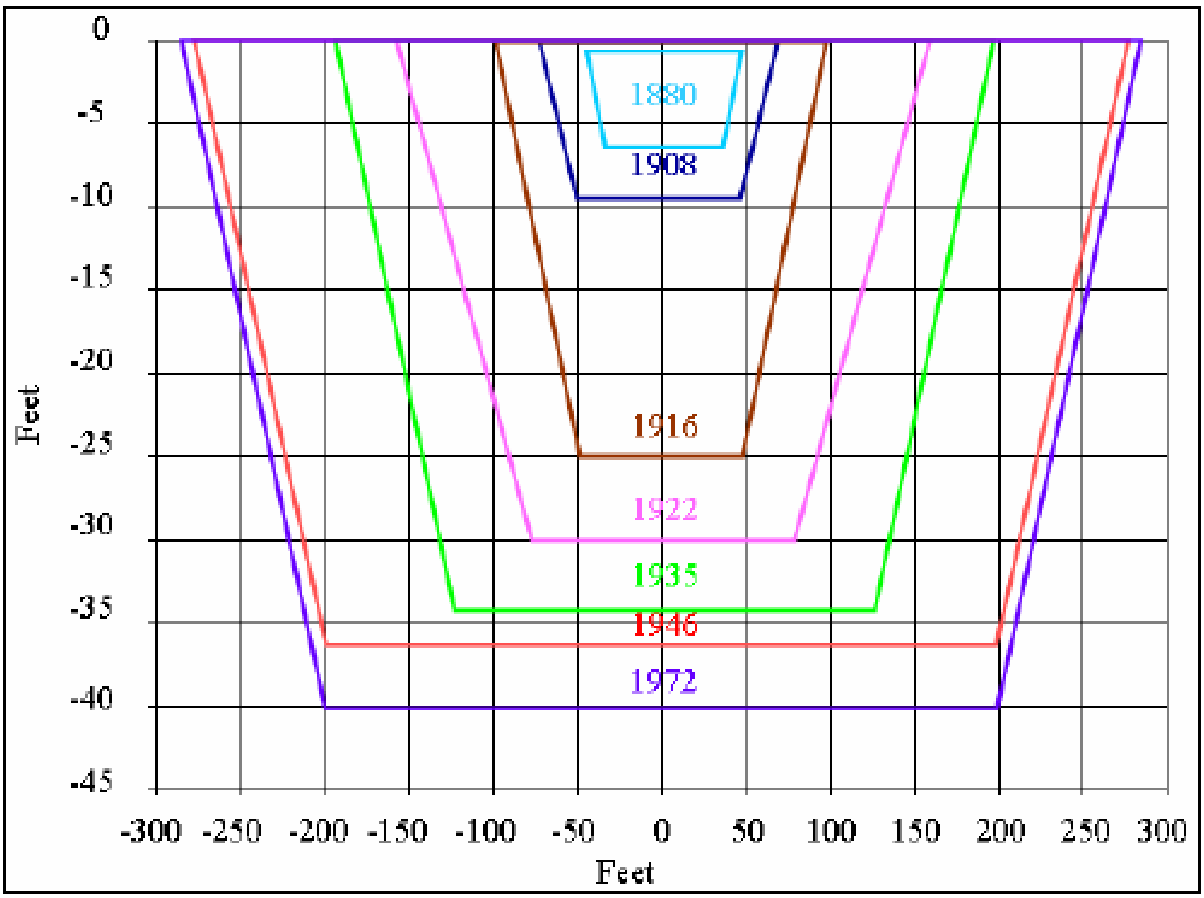

Figure O-3. Historical Channel Dimensions of the Sabine-Neches Ship Channel
(Source: LCWCRTF, 2002)

Saline water from the Gulf of Mexico travels up the Sabine-Neches channel, resulting in an atypical estuarine salinity gradient. Construction of the Sabine-Neches Ship Channel and the deepening of both rivers, in conjunction with increased withdrawals of freshwater upstream for industry and agriculture, have resulted in major changes in system hydrology and saltwater intrusion in both Texas and Louisiana. The channel also funnels freshwater inflows more directly to the Gulf, largely bypassing the adjacent marshes in Louisiana and Texas (LCWCRTF, 2002).

c. The Gulf Intracoastal Waterway. The GIWW from the Sabine River to the Calcasieu River was constructed in 1913-1914 with a width of 40 feet and a depth of 5 feet. In 1925, the channel was enlarged to 100 feet wide by 9 feet deep. Prior to the deepening of the Calcasieu Ship Channel in the late 1930s, the GIWW reach from the Sabine River to the Calcasieu River was deepened to 30 feet to facilitate navigation to the Port of Lake Charles. This section was then known as the Lake Charles Deep Water Channel. In 1941, the channel was thereafter maintained as part of the GIWW, at a depth of 12 feet and a width of 125 feet (USDA, 1994, in LCWCRTF, 2002).

Construction of the GIWW significantly altered regional hydrology by connecting the two major ship channels. Prior to the construction of the GIWW, the Calcasieu and Sabine estuaries were mostly distinct and were more influenced by the Calcasieu and Sabine Rivers, respectively. The Gum Cove Ridge once separated the Sabine Basin from the Calcasieu Basin, with little water exchange between the two. Removing the mouth bars and deepening the Calcasieu and the Sabine-Neches channels, as well as the GIWW and interior canals bisecting the Gum Cove Ridge, dramatically altered the hydrology of what were once separate basins, merging them into the present-day Calcasieu-Sabine Basin. In addition to effectively combining the two basins, the GIWW cut off all the natural bayous and upland sheet flow that historically affected marshes, and channelized more freshwater inflow to the Gulf of Mexico (LCWCRTF 2002).

B. Present Action - Land Management and Wetland Restoration

1. Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA). Numerous land stewardship projects have been implemented in the Calcasieu- Sabine basin to help restore its estuaries and protect its shoreline. Table O-1 lists completed and ongoing restoration and management projects in the basin funded by CWPPRA. These projects have or are expected to have beneficial impacts on natural resources in the study area. The CWPPRA was the first Federal statutory mandate for restoration of Louisiana's coastal wetlands. As of May 2013, 196 active CWPPRA projects have been approved, 99 have been constructed, 20 are under construction, and 43 have been de-authorized or transferred to other programs. Many of these projects have occurred in the Calcasieu River and Ship Channel project area, located mainly in Calcasieu Lake.

Table O-1. CWPPRA Restoration Sites for the Calcasieu-Sabine Basin
(Source: http://lacoast.gov/new/Projects/List.aspx)

Agency	Project Name	Type	Net Benefit After 20 Years (acres)
NRCS	Black Bayou Culverts Hydrologic Restoration	Hydrologic Restoration	540
NMFS	Black Bayou Hydrologic Restoration	Hydrologic Restoration	3,594
NRCS	Brown Lake Hydrologic Restoration	Hydrologic Restoration	282
USFWS	Cameron Creole Plugs	Hydrologic Restoration	865
NMFS	Cameron Meadows Marsh Creation and Terracing	Marsh Creation, Terracing	264
NRCS	Cameron-Creole Freshwater Introduction	Freshwater Diversion	473
NRCS	Cameron-Creole Maintenance	Hydrologic Restoration	2,602
USFWS	Cameron-Creole Watershed Grand Bayou Marsh	Marsh Creation	534
Corps	Clear Marais Bank Protection	Shoreline Protection	1,067
NRCS	East Mud Lake Marsh Management	Marsh Management	1,520
USFWS	East Sabine Lake Hydrologic Restoration	Hydrologic Restoration	225
NRCS	GIWW - Perry Ridge West Bank Stabilization	Shoreline Protection	83
NRCS	Highway 384 Hydrologic Restoration	Hydrologic Restoration	150
NRCS	Holly Beach Sand Management	Shoreline Protection	330
NRCS	Kelso Bayou Marsh Creation	Marsh Creation	274
NMFS	Oyster Bayou Marsh Restoration	Marsh Creation, Terracing	489
NRCS	Perry Ridge Shore Protection	Shoreline Protection	1,203
NRCS	Plowed Terraces Demonstration	Sediment and Nutrient Trapping, Demo	N/A
USFWS	Replace Sabine NWR Water Control Structures at HQ Canal, W Cove Canal, and Hog Island Gully	Marsh Management	953
USFWS	Sabine NWR Erosion Protection	Shoreline Protection	5,542
Corps	Sabine NWR Marsh Creation, Cycle 1	Marsh Creation	214
Corps	Sabine NWR Marsh Creation, Cycle 2	Marsh Creation	261
Corps	Sabine NWR Marsh Creation, Cycle 3	Marsh Creation	187
Corps	Sabine NWR Marsh Creation, Cycle 4	Marsh Creation	163
Corps	Sabine NWR Marsh Creation, Cycle 5	Marsh Creation	168
NRCS	Sweet Lake/Willow Lake Hydrologic Restoration	Shoreline Protection	5,796
NRCS	West Hackberry Vegetative Planting Demonstration	Vegetative Planting Demo	N/A

NRCS – Natural Resources Conservation Service
NMFS - National Marine Fisheries Service
USFWS – US Fish & Wildlife Service

2. Coastal Impact Assistance Program (CIAP). An Environmental Assessment has recently been completed by the Corps for the Black Lake (Marcantel) property. The Port and the state received CIAP funds and the Minerals Management Service (now the Bureau of Ocean Energy Management) agreed that such funds could be used as gratuitous contribution for 100 percent incremental cost for the beneficial use of dredged material at Black Lake. The Finding of No Significant Impact was signed November 7, 2008. This disposal site would restore approximately 350 acres of eroded marsh approximately 1 mile south of the GIWW, along the former northern/northwestern rim of Black Lake. The general purpose of the project would be to create a diversity of habitat from beneficially used dredged material from maintenance of the Calcasieu Ship Channel.

C. Reasonably Foreseeable Future Actions. The Corps anticipates continuing maintenance of the Calcasieu Lock indefinitely. Other reasonably foreseeable future actions, which may contribute to cumulative impacts, include:

1. Calcasieu River and Pass Navigation Dredged Material Management Plan (DMMP). The project was authorized by the River and Harbors Act of 1946 and subsequent amendments. The DMMP was being developed under the Operations & Maintenance of the Calcasieu River and Pass project. Dredged material management planning for all Federal harbor projects is conducted by the Corps to ensure that maintenance dredging activities are performed in an environmentally acceptable manner, use sound engineering techniques, are economically warranted, and that sufficient confined disposal facilities are available for at least the next 20 years. These plans address dredging needs, disposal capabilities, capacities of disposal areas, environmental compliance requirements, and potential for beneficial use of dredged material, and indicators of continued economic justification. The Corps anticipates continuing maintenance dredging of the Calcasieu Ship Channel indefinitely. The Final Report and Supplemental Environmental Impact State was completed in November 2010. It identified 23 disposal sites from Lake Charles to the Gulf along with 6 beneficial use sites. Two placements sites are near the Calcasieu Lock Project

2. Coastal Wetlands Planning, Protection and Restoration Act. It is anticipated that additional CWPPRA projects would be implemented in the vicinity of Calcasieu Lake.

3. Coastal Impact Assistance Program. The CIAP was originally authorized by Congress in 2001 in the Outer Continental Shelf (OCS) Lands Act, as amended (31 U.S.C. 6301-6305). Section 384 of the Energy Policy Act of 2005 (Public Law 109-58) authorized CIAP funds to be distributed to OCS oil and gas producing states to mitigate the impacts of OCS oil and gas activities for fiscal years 2007 through 2010. The state liaison for this program is the Louisiana Department of Natural Resources. The CIAP allocations have been used to fund various state and local coastal activities and projects including: monitoring, assessment, research, and planning; habitat, water quality, and wetland restoration; coastline erosion control; and control of invasive non-native plant and animal species.

4. Construction of a General Anchorage in the Calcasieu Ship Channel. Deep-draft vessel traffic on the Calcasieu Ship Channel suffers costly delays due to the width of the inland reach of the ship channel, which prohibits most deep-draft vessels from passing head-on in the channel. These delays are exacerbated by liquefied natural gas (LNG) vessel traffic, which cannot meet and pass in the ship channel, including the 32-mile long Gulf reach. The Corps undertook a feasibility study to construct anchorage areas along the channel where deep-draft vessels can layover closer to their destinations and to provide passing lanes where non-LNG vessels can meet and pass closer to their destinations. The study looked at a number of alternatives, including anchorage areas at RM 26 and 29, and a combination of both. The study recommended building an anchorage at RM 29. The data and findings were turned over to the Port in January 2011. At that time, the Port decided to terminate the study and pursue construction on its own due to the low cost of construction ($5.5M) and the time it may take to get the project

5. Construction of New LNG Terminals. Onshore regasification facilities that use imported LNG have been in existence in the U.S. since 1969. However, only four were constructed, the largest of which is the Trunkline facility. Two new LNG facilities have been approved by the Federal Energy Regulatory Commission to be constructed in the project area: the Cameron LNG, owned by Sempra Energy, and the Creole Trail LNG, owned by Cheniere LNG. Future installation of LNG terminals should be evaluated for environmental impacts and required mitigation.

6. The Trans-Texas Water Program. The 1968 Texas Water Plan was prepared by the Texas Water Development Board as a comprehensive 50-year plan for securing the future water supply needs of the State of Texas. Recommendations for the program include the transfer of surplus “state” waters from basins having surplus supplies to basins that experience water shortages. The Sabine River was identified as one source of freshwater for southeast Texas. Potential adverse effects of altering river inflows to the Sabine Basin should be mitigated or avoided.

7. Rycade Canal Hydrologic Restoration Project. The Rycade Canal project (C/S-02) is a semi-impounded marsh management project located in Cameron Parish, Louisiana. The project area consists of approximately 6,575 acres of brackish marsh in and adjacent to the Sabine NWR in Cameron Parish. Rycade Canal, built in the 1940s as an oil well location canal, is an avenue for salt water from the GIWW via Black Lake, and from the Calcasieu Ship Channel via Hog Island Gully. The project objectives are to protect low salinity marsh by reducing rapid water fluctuations and water circulation patterns that encourage salt water intrusion and tidal scouring, and reestablish historic hydrologic boundaries and flow patterns by structural repairs, levee repair/reconstruction, and embankment repair on the GIWW.

8. Southwest Coastal Louisiana Feasibility Study. The WRDA of 2007 authorized funding for a number of coastal restoration and hurricane protection projects in the Louisiana Coastal Area. Section 7010 included the *Southwest Coastal Louisiana Hurricane and Storm Damage Reduction Study*. A reconnaissance study completed in 2007, which recommended levee alternatives, was broadened in focus by the state and the Corps to include both levee and restoration alternatives. The Corps and the state have agreed to cost-share a feasibility study that will include building levees and undertaking coastal restoration projects to protect populated areas in Vermilion, Calcasieu, and Cameron Parishes while improving wildlife habitat. The Study will include an environmental impact statement engineering appendix with baseline cost estimates, and other supporting appendices documenting the formulation of hurricane protection and coastal restoration alternatives. The feasibility study is scheduled to produce a Chief's report in September 2014. The proposed action is likely to be based on some combination of flood risk management and ecosystem restoration projects. This represents the first time a coastal protection and hurricane protection study has been undertaken for Southwest Louisiana.

9. Section 204 Study, Calcasieu River and Pass Project, Mile 5-14. The WRDA 2007 provided for the funding of a Continuing Authorities Program (CAP) study under Section 204 of WRDA

1992 to use the material from maintenance dredging to restore/rehabilitate estuarine marsh habitat along the eastern shore of Lake Calcasieu. The CAP 204 program would be used to pay the incremental costs between the Federal standard and the beneficial use of the same material. Several potential sites have been identified for the receipt of material dredged from the Calcasieu River and Pass, Louisiana Project between channel miles 5.0 and 14.0. Sites covered by the 2010 proposed Dredged Material Management Plan/SEIS for Calcasieu River and Pass would be eliminated from consideration for the CAP 204 project, as those would become part of the definition of the Federal standard. A feasibility study conducted by MVN is currently ongoing.

10. **Louisiana's 2012 Coastal Master Plan, 2012.** The Master Plan was developed to fulfill the mandates of Act 8, which was passed by the Louisiana Legislature in November 2005. The Act created the Coastal Protection and Restoration Authority of Louisiana (CPRA) and charged it with coordinating the efforts of local, state, and Federal agencies to achieve long-term and comprehensive coastal protection and restoration. Act 8 also requires that the CPRA establish a clear set of priorities for making comprehensive coastal protection a reality in Louisiana. Toward that end, the CPRA set five major goals:

    1. Present a conceptual vision for a sustainable coast.
    2. Be a living document that changes over time as understanding of the landscape improves and technical advances are made.
    3. Emphasize sustainability of ecosystems, flood protection, and communities.
    4. Integrate flood control projects and coastal restoration initiatives to help both human and natural communities thrive over the long-term.
    5. Be clear about unknowns. There is a need for additional scientific and technical advancements to better predict the future of the coast.

    In 2007 a Comprehensive Plan was developed. Per the authorizing legislation, the Master Plan was updated in 2012. The Plan identifies hundreds of projects across south Louisiana. Two primary factors drove the States decision about future projects that should be in the 2012 Coastal Master Plan.

    1. How well did the projects reduce flood risk?
    2. How well did the projects build new land or sustain the land we already have?

    The Plan identifies four Bank Stabilization, four Hydraulic Restoration and two Marsh Creation Projects in the vicinity of Calcasieu Lock with most being in and around Calcasieu Lake and the GIWW channel. The Calcasieu Lock Feasibility Study does address one project in the Hydrologic Restoration category which calls for a new lock to manage Mermentau Basin flows. The Master Plan can be found http://www.coastalmasterplan.louisiana.gov/

V. INCREMENTAL EFFECTS OF THE PROPOSED PROJECT

Cumulative impacts associated with past actions have produced a natural environment that is markedly different from that of 140 years ago. However, the Calcasieu estuary is still a valuable ecosystem. The proposed project would maintain a saltwater barrier at the lock, would not affect the overall dimensions of the GIWW, and therefore would not exacerbate existing salinity issues. The proposed project would result in the loss of about 14 acres of marsh, but also includes the restoration or creation of about 35 acres of marsh through the placement of dredge material for beneficial use. The environmental effects of the proposed project would not contribute adverse increments to the cumulative effects of past, present, and reasonably foreseeable actions.

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CALCASIEU LOCK LOUISIANA
FEASIBILITY STUDY

APPENDIX P

WETLAND VALUE ASSESSMENT
METHODOLOGY AND RESULTS

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WETLAND VALUE ASSESSMENT
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CALCASIEU LOCK LOUISIANA
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APPENDIX P

WETLAND VALUE ASSESSMENT
METHODOLOGY AND RESULTS

I. INTRODUCTION

This appendix describes the Wetland Value Assessments(WVA) that were developed for the Calcasieu Lock Feasibility Study. The Project area, located in Calcasieu Parish, southwestern Louisiana, is within the state's designated coastal zone.

There are three main types of habitat in the Project area. Coastal marsh, the predominant type, is represented by brackish marsh to the west of Louisiana Highway 384 (Big Lake Rd) and intermediate marsh to the east. These marshes consist of emergent vegetation interspersed with and bordered by shallow open water. Deeper areas of open water distinct from marsh are represented by the Gulf Intracoastal. Waterway (GIWW), Black Bayou, and smaller contiguous water bodies. All these habitats are aquatic. Lastly, a small component of terrestrial habitat occurs along the south side of the GIWW in the vicinity of the existing lock. This upland habitat consists of a linear forested spoil bank. It was created about 60 years ago during construction of the lock when dredged material was deposited and eventually colonized by volunteer plant species. The higher elevations of the spoil bank are forested (about half the area), whereas the lower elevations which border the trees consist of scrub-shrub vegetation.

The potential for all project alternatives to adversely affect any of these habitats was assessed by an interagency Habitat Evaluation Team (HET). The HET was represented by federal and state natural resource agencies expressing interest in participating in the habitat evaluation, and for this project included the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the Natural Resources Conservation Service, and the US Army Corps of Engineers (Corps).

Alternatives 1 and 2 would provide a new channel through which freshwater flows stemming from rainfall events over the Mermentau Basin to the east would be diverted around the existing Calcasieu Lock. Construction of this channel would result in unavoidable direct impacts to brackish marsh and forested spoil bank habitats. Alternatives 3, 4, and 5 would use Black Bayou to divert freshwater flows through, and unavoidable direct impacts would occur to brackish and intermediate marsh habitats.

With regard to the project alternatives as a whole, the HET recognized that each alternative presented the opportunity to use dredged material in a beneficial manner to restore and create marsh habitat to potentially offset project losses to marsh habitat. It also became evident that disposal of dredged material in nearby shallow open water areas represented the least-cost disposal alternative for each project alternative.

II. METHODOLOGY

For the Calcasieu Lock project, the WVA methodology relies on the use of the Coastal Marsh and Chenier/Ridge Community Models, which were developed by the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) Environmental Work Group (EnvWG) to determine the suitability of marsh and open water habitats as well as chenier/ridge habitats in the Louisiana coastal zone. The purpose of the WVA is to define an optimal combination of habitat conditions for all fish and wildlife species living in Louisiana coastal marsh and chenier/ridge ecosystems. Section II.A. and Section II.B. explain the methodology used to develop the Coastal Marsh and Chenier/Ridge Community Models, respectively. These sections are excerpts from the CWPPRA EnvWG Wetland Value Assessment Methodology for the Coastal Marsh Community Models (Roy 2012, pages 13 - 27) and the Coastal Chenier/Ridge Community Model (Roy 2010, pages 1 – 4). Please refer to those documents for more information.

The WVA methodology and three models used in this analysis have been approved for use as planning tools for habitat impact assessment of water resource projects in coastal Louisiana that are proposed by the Corps (USACE, undated). The models used include the following:

- Fresh/Intermediate Coastal Marsh Community Model, version 1.1 (dated Nov 15, 2011; Roy 2012);
- Brackish Coastal Marsh Community Model, version 1.1 (dated Nov 15, 2011; Roy 2012);
- Coastal Chenier/Ridge Community Model, version 1.1 (dated Nov 18, 2011; Roy 2010).

A. Coastal Marsh Community Model

(The following italicized sections are excerpts from Roy, 2012)

1. Variable Selection. *The foundation of each coastal marsh community model is a suite of habitat variables deemed important to coastal fish and wildlife species. Variables were selected through a two-part procedure. The first involved a listing of environmental variables thought to be important in characterizing fish and wildlife habitat in coastal marsh ecosystems. The second part involved reviewing variables used in species-specific HSI models published by the U.S. Fish and Wildlife Service. Review was limited to HSI models for those fish and wildlife species known to inhabit Louisiana coastal wetlands, and included models for 10 estuarine fish and shellfish, 4 freshwater fish, 12 birds, 3 reptiles and amphibians, and 3 mammals* (Table P-1). *The number of models included from each species group was dictated by model availability and those selected are intended to represent a composite of the overall fish and wildlife community. Exclusion of certain species groups is not intended.*

Selected HSI models were then grouped according to the marsh type(s) used by each species. Because most species are not restricted to one marsh type, most models were included in more than one marsh type group. Within each wetland type group, variables from all models were then grouped according to similarity (e.g., water quality, vegetation, etc.). Each variable was evaluated based on 1) whether it met the variable selection criteria; 2) whether another, more easily measured/predicted variable in the same or a different similarity group functioned as a surrogate; and 3) whether it was deemed suitable for the WVA application (e.g., some freshwater fish model variables dealt with riverine or lacustrine environments). Variables that did not satisfy those conditions were eliminated from further *consideration. The remaining variables, still in their similarity groups, were then further eliminated or refined by combining similar variables and/or culling those that were functionally duplicated by variables from other models (i.e., some variables were used frequently in different models in only slightly different format).*

Table P-1. *HSI Models Consulted for Variables for Possible Use in the Coastal Marsh Models*

Estuarine Fish and Shellfish	Birds	Mammals	Freshwater Fish	Reptiles and Amphibians
Pink Shrimp	White-fronted Goose	Mink	Channel Catfish	Slider Turtle
White Shrimp	Clapper Rail	Muskrat	Largemouth Bass	American Alligator
Brown Shrimp	Great Egret	Swamp Rabbit	Redear Sunfish	Bullfrog
Spotted Seatrout	Northern Pintail		Bluegill	
Gulf Flounder	Mottled Duck			
Southern Flounder	American Coot			
Gulf Menhaden	Marsh Wren			
Juvenile Spot	Snow Goose			
Juvenile Atlantic Croaker	Great Blue Heron			
Red Drum	Laughing Gull			
	Red-winged Blackbird			
	Roseate Spoonbill			

Source: Roy, 2012

Variables selected from the HSI models were then compared to those identified in the first part of the selection procedure to arrive at a final list of variables to describe wetland habitat quality. That list includes six variables for each marsh type; 1) percent of the wetland area covered by emergent vegetation, 2) percent open water covered by submerged aquatic vegetation, 3) marsh edge and interspersion, 4) percent of the open water area $\leq$ 1.5 feet deep, 5) salinity, and 6) aquatic organism access.

2. Suitability Index (SI) Graph Development. *Each model contains Suitability Index graphs for each variable. SI graphs are unique to each variable and define the relationship between that variable and habitat quality. A variety of resources was utilized to construct each SI graph, including the HSI models from which the final list of variables was partially derived, consultation with other professionals and researchers outside the EnvWG, published and unpublished data and studies, and personal knowledge of EnvWG members. A review of contemporary, peer-reviewed scientific literature was also conducted for each of the variables, providing ecological support for the form of the SI graph for each of the variables. The process of SI graph development was one of constant evolution, feedback, and refinement; the form of each SI graph was decided upon through consensus among EnvWG members.*

Nearly all of the SI graphs have a minimal SI of 0.1. This is because any area that falls into the cover types addressed by the WVA models provides some habitat value. For example, areas consisting of 100% open water have habitat value to many species of fish and wildlife. Likewise, if an area has no submerged aquatic vegetation, it still has habitat value. Even open water areas with no shallow water (<=1.5 feet) still have habitat value as deep open water can serve as drought refugia for fish and alligators.

The Suitability Index graphs were developed according to the following assumptions:

Variable V_1 - Percent of Wetland Area Covered by Emergent Vegetation. *Persistent emergent vegetation (i.e., emergent marsh) plays an important role in coastal wetlands by providing foraging, resting, and breeding habitat for a variety of fish and wildlife species; and by providing a source of detritus and energy for lower trophic organisms that form the basis of the food chain. An area with no emergent vegetation (i.e., shallow open water) is assumed to have minimal habitat suitability in terms of this variable, and is assigned an SI of 0.1. Optimal vegetative coverage (i.e., percent marsh) is assumed to occur at 100 percent (SI=1.0). That assumption is dictated primarily by the constraint of not having graph relationships conflict with CWPPRA's purpose of long-term restoration and protection of vegetated wetlands. The EnvWG originally developed a strictly biologically-based graph defining optimal habitat conditions at marsh cover values between 50 and 70 percent, and sub-optimal habitat conditions outside that range. However, application of that graph, in combination with the time analysis used in the evaluation process (i.e., 20-year project life), often reduced project benefits or generated a net loss of habitat quality through time with the project. Those situations arose primarily when: existing (baseline) emergent vegetation cover exceeded the optimum (>70 percent); the project was predicted to maintain baseline cover values; and without the project the marsh was predicted to degrade, with a concurrent decline in percent emergent vegetation into the optimal range (50-70 percent). The time factor worsened the situation when the without-project degradation was not rapid enough to reduce marsh cover values significantly below the optimal range, or below the baseline SI, within the 20-year evaluation period. In those cases, the analysis would show net negative benefits for the project, and positive benefits for allowing the marsh to degrade rather than maintaining the existing marsh. Coupling that situation with the presumption that marsh conditions are not static*; Louisiana is losing marsh faster than any other place in the U.S. – one football field of marsh becomes water about every 30 minutes (Final Programmatic EIS for the LCA Ecosystem Restoration Study, 2004); and taking into account the purpose of CWPPRA, the EnvWG decided that, all other factors being equal, the models should favor projects that maximize marsh creation, maintenance, and protection. Therefore, the EnvWG agreed to deviate from a strictly biologically-based habitat suitability index graph for V_1 and established optimal habitat conditions at 100 percent marsh cover.

In each coastal marsh model, this variable is weighted the highest and thus influences project benefits the most. Of the six variables, future projections for V1 require the most thought and are usually discussed at length during the WVA process.

FWOP projections for V1 typically involve applying the baseline land loss rate to the existing marsh acreage for the project lifespan. Whichever method is selected, a spreadsheet which calculates land loss annually should be used. Under some FWOP scenarios, that loss rate may be increased or decreased depending on expected changes in the project area. The effects of salinity, subsidence, erosion, breaching of a shoreline/bank, constructed projects in the area, future projects in the area, and any other factor which may alter the loss rate should be considered. The evaluation should include a TY when those changes are expected to occur.

FWP projections should address the changes expected to occur as a result of project implementation. The effects of the project on salinity, subsidence, nutrient availability, sediment availability, and any other factor affecting marsh loss should be considered. The planner should carefully consider the causes of loss in the area and the effects of the project on those causes. Future projections should be supported by monitoring data, scientific literature, examples of project success in other areas, previous WVAs, or personal knowledge of the project area. In some instances, best professional judgment provides the only basis for future projections. However, supporting data and other information should be thoroughly reviewed before relying solely on best professional judgment.

The EnvWG has adopted V1 conventions for certain project types. Although these conventions are generally applied, exceptions are sometimes proposed and may be accepted by the group. It is the responsibility of the project planner to provide justification in the Project Information Sheet for deviating from these conventions.

[The project types for which conventions have been developed include marsh creation, marsh nourishment, shoreline protection, diversions, and crevasses. Conventions for marsh creation only are presented here, since that is the only type applicable to this project]:

> <u>Marsh Creation</u> – *Marsh creation involves filling open water areas with dredged sediment to create marsh. Therefore, only the open water acres filled with sediment within the project area are considered as marsh creation. Emergent marsh which is covered with dredged material is considered as marsh nourishment and treated separately. Elevation (as surrogate for hydroperiod) and plant colonization are guiding factors for assignment of marsh functionality. At TY1, marsh creation projects typically receive credit for 25% of the created area if vegetative plantings are included as a project component and implemented in TY1. It is assumed that a standard vegetative planting design (10'X5' spacing), will yield 25% coverage at the end of TY1 (i.e., after one growing season). Even with vegetative plantings, coverage is not sufficient at TY1 for the entire marsh platform to be given credit as fully functional marsh. At TY3, it is assumed that containment dikes have degraded (i.e., naturally or by mechanical means) and that the marsh platform has vegetated and consolidated to the point where it can achieve minimum wetland functions as necessary for the overall fish and wildlife community. The entire marsh platform receives full credit at that time. If vegetative plantings are not included as a project component, then 10% credit is applied at TY1, 30% at TY3, and 100% credit at TY5. If design information (e.g., settlement curves) indicates higher elevations will prevail, full functionality will be delayed.*
>
> *Exceptions to these conventions are sometimes applied such as when the project area is located within a fresh system such as the Atchafalaya or Mississippi River deltas. Fresh environments can often naturally vegetate much more rapidly than brackish or saline areas, especially within river deltas.*
>
> *The inclusion of tidal creeks (dredged prior to or after construction) also increases functional marsh credit. Tidal creeks provide greater connectivity, increased edge, and overall greater habitat diversity. If the acreage of tidal creeks is at least 2% of the marsh platform, then functional marsh credit is increased from 30% to 35% at TY3 for unplanted sites. To avoid penalizing a project for the addition of this beneficial feature, the tidal creek acreage is not subtracted from the acreage of marsh when calculating the percent marsh value for V1. Doing so would negate the benefits received from the increase in functional marsh credit at TY3.*

Typically, a 50% reduction in the FWOP marsh loss rate is applied to marsh creation projects under FWP. It is assumed that the higher elevation and better soil conditions of the created marsh provide for a more resilient marsh which will be lost at a reduced rate. To date, CWPPRA marsh creation projects have performed well in terms of marsh loss. However, most CWPPRA marsh creation projects are early in their project life and little can be said regarding long-term performance. To assess performance over time, a frequency of inundation analysis may be conducted if sufficient data are available.

Note: The above assumptions may not suffice for non-CWPPRA projects evaluated over a 50-year project life when sea level rise and subsidence have a greater impact on project performance or when the project premise is compensatory mitigation to ensure no net loss of habitat.

Variable V_2 - Percent Open Water Covered by Submerged Aquatic Vegetation (SAV). *The baseline (TY0) value for this variable often cannot be estimated in coastal Louisiana via visual estimates of cover because turbidity generally is great enough to obscure SAV even when SAV almost covers pond bottoms (e.g. Merino et al. 2005). SAV abundance varies so much that neither estimates of biomass (via cores) nor objective measures of percent cover (estimated from presence/absence on a garden rake touched at numerous points across a pond) are effective alone. Biomass estimates are preferred but estimating biomass is inefficient when SAV beds are small and few. At the other end of the spectrum, estimating the percent of pond bottom covered by SAV fails to provide meaningful information when SAV beds cover virtually the entire pond bottom but plant stature varies spatially. Furthermore, SAV is temporally dynamic in coastal Louisiana with great differences among years (Nyman and Chabreck 1996) and within years but lacks seasonal patterns within years (Merino et al. 2005). For these reasons, the WVA often utilizes best professional judgment along with whatever data is available to generate input data for SAV. Greater emphasis is placed on salinity and marsh type, as indicated by the observations of Chabreck (1971), with secondary emphasis placed on turbidity as indicated by the observations that terraces improve water clarity and increase SAV abundance (Bush Thom et al. 2004, O'Connel and Nyman in press).*

Fresh and intermediate marshes often support diverse communities of floating-leaved and submerged aquatic plants that provide important food and cover to a wide variety of fish and wildlife species. A fresh/intermediate open water area with no aquatics is assumed to have low suitability (SI=0.1). Optimal conditions (SI=1.0) are assumed to occur when 100 percent of the open water is dominated by aquatic vegetation. Habitat suitability may be assumed to decrease with aquatic plant coverage approaching 100 percent due to the potential for mats of aquatic vegetation to hinder fish and wildlife utilization; to adversely affect water quality by reducing photosynthesis by phytoplankton and other plant forms due to shading; and contribute to oxygen depletion spurred by warm-season decay of large quantities of aquatic vegetation. The EnvWG recognized, however, that those effects were highly dependent on the dominant aquatic plant species, their growth forms, and their arrangement in the water column; thus, it is possible to have 100 percent cover of a variety of floating and submerged aquatic plants without the above-mentioned problems due to differences in plant growth form and stratification of plants through the water column. Because predictions of which species may dominate at any time in the future would be tenuous, at best, the EnvWG decided to simplify the graph and define optimal conditions at 100 percent SAV cover.

Brackish marshes also have the potential to support aquatic plants that serve as important sources of *food and cover for several species of fish and wildlife. Although brackish marshes generally do not support the amounts and kinds of aquatic plants that occur in fresh/intermediate marshes, certain species, such as widgeon-grass, and coontail and milfoil in lower salinity brackish marshes, can occur abundantly under certain conditions. Those species, particularly widgeon-grass, provide important food and cover for many species of fish and wildlife. Therefore, the V_2 Suitability Index graph in the brackish marsh model is identical to that in the fresh/intermediate model.*

Some low-salinity saline marshes may contain beds of widgeon-grass and open water areas behind some barrier islands may contain dense stands of seagrasses (e.g., Halodule wrightii and Thalassia testudinum). However, saline marshes typically do not contain an abundance of aquatic vegetation as often found in fresh/intermediate and brackish marshes. Open water areas in saline marshes typically contain sparse aquatic vegetation and are primarily important as nursery areas for marine organisms. Therefore, in order to reflect the importance of those open water areas to marine organisms, a saline marsh lacking aquatic vegetation is assigned a SI=0.3. It is assumed that optimal coverage of aquatic plants occurs at 100 percent.

Future projections for V2 should consider changes in salinity, freshwater introduction, nutrient input, turbidity, water depth, fetch, and other factors which affect SAV growth. Perhaps the two most important factors to consider under FWOP and FWP conditions are salinity and nutrient input as SAV growth is highly dependent on each of those factors. Few standard conventions have been adopted for projecting V2. Future projections should be supported by monitoring data, scientific literature, examples of project success in other areas, previous WVAs, or personal knowledge of the project area.

Variable V_3 - Marsh Edge and Interspersion. *This variable takes into account the relative juxtaposition of marsh and open water for a given marsh:water ratio. The baseline (TY0) value for this variable is determined by examining recent aerial photography of the project area and comparing it to the interspersion classes illustrated* in figures P-1 through P-4. T*he project area may be divided into different interspersion classes as many areas contain more than one class. As with all variables, the baseline interspersion classes are discussed by the group and there is usually a group examination of the aerial photos.*

Interspersion is especially important when considering the value of an area as foraging and nursery habitat for freshwater and estuarine fish and shellfish and associated predators (e.g., wading birds); the marsh/open water interface represents an ecotone where prey species often concentrate, and where post-larval and juvenile organisms can find cover. Isolated marsh ponds are often more productive in terms of aquatic vegetation than are larger ponds due to decreased turbidity, and, thus, may provide more suitable waterfowl habitat. However, certain interspersion classes can be indicative of marsh degradation, a factor taken into consideration in assigning suitability indices to the various interspersion classes.

A relatively high degree of interspersion in the form of tidal channels and small ponds (Class 1) is assumed to be optimal (SI=1.0); tidal channels and small ponds offer interspersion, yet are not indicative of active marsh deterioration. Numerous small marsh ponds (Class 2) offer a high degree of interspersion, but can be indicative of the onset of marsh break-up and deterioration, and are therefore assigned a lower SI of 0.6.

Large ponds (Class 3) and open water areas with little surrounding marsh (Class 4) offer lower *interspersion values and usually indicate advanced stages of marsh loss. Therefore, Classes 3 and 4 are assigned SIs of 0.4 and 0.2, respectively. Also grouped within Class 3 are areas of "carpet" marsh which contain no or relatively insignificant tidal channels, creeks, trenasses, ponds, or other features of interspersion but may still provide habitat for aquatic organisms during tidal flooding.*

Terrace fields are typically constructed in areas generally classified as Class 4 or Class 5. The addition of terraces can significantly increase the amount of marsh edge and interspersion. Depending on the distance between terrace rows, the addition of terraces can result in areas classified as Class 4/5 improving to Class 3. If the distance between terrace rows is 300 feet or less, the EnvWG assigns a Class 3 designation. Terrace rows spaced greater than 300 feet apart do not receive a Class 3 designation and will likely be classified as Class 4.

Class 5 is characterized as a very advanced stage of marsh deterioration consisting of small marsh islands (i.e., a range of 0% to 10% marsh) or areas made up entirely of open water. Habitat of this type provides little to no marsh edge and its function as nursery habitat for marine organisms or foraging habitat for avian predators has been significantly reduced. Although habitats represented by this classification are predominantly unvegetated open water areas, they still provide habitat for many fish and shellfish species and provide loafing areas for waterfowl and other waterbirds. Class 5 is assigned an SI of 0.1. Also grouped within Class 5 are areas characterized as solid land with no interspersion features and little to no vegetation. Newly created marsh with no ponds, creeks, or other tidal features would fall within this class.

Future projections for this variable can be difficult. It requires the project planner to develop a mental picture of what the project area will look like after 20 years (and for intermediate years) of marsh loss under FWOP and also under improved conditions for FWP. One technique which may assist with that process is reviewing aerial photos of other areas with similar conditions to those projected.

There are a few standard conventions which have been adopted for this variable. The percentages of marsh and open water can sometimes be used to determine the amount of the project area to assign to each interspersion class. For example, if an area is 50% marsh and 50% open water and the water area is large and contiguous, then the area could be classified as 40% Class 1 and 60% Class 4. A small amount of marsh is included within or around the large open water area associated with Class 4; thus, 60% of the area is characterized as Class 4. Assignment of interspersion Class 5 should be reserved for those areas which are entirely open water or contain a very small percentage of marsh (< 5%).

Marsh creation/nourishment projects are assigned Class 5 (i.e., no interspersion) at TY1, Class 3 (i.e., marsh platform with little interspersion features) at TY3, and Class 1 at TY5. Incorporation of tidal creeks and ponds may expedite the level of interspersion assigned after TY1.

Figure P-1. Marsh Edge and Interspersion Class 1 (Roy, 2012)

Figure P-2. Marsh Edge and Interspersion Class 2 (Roy, 2012)

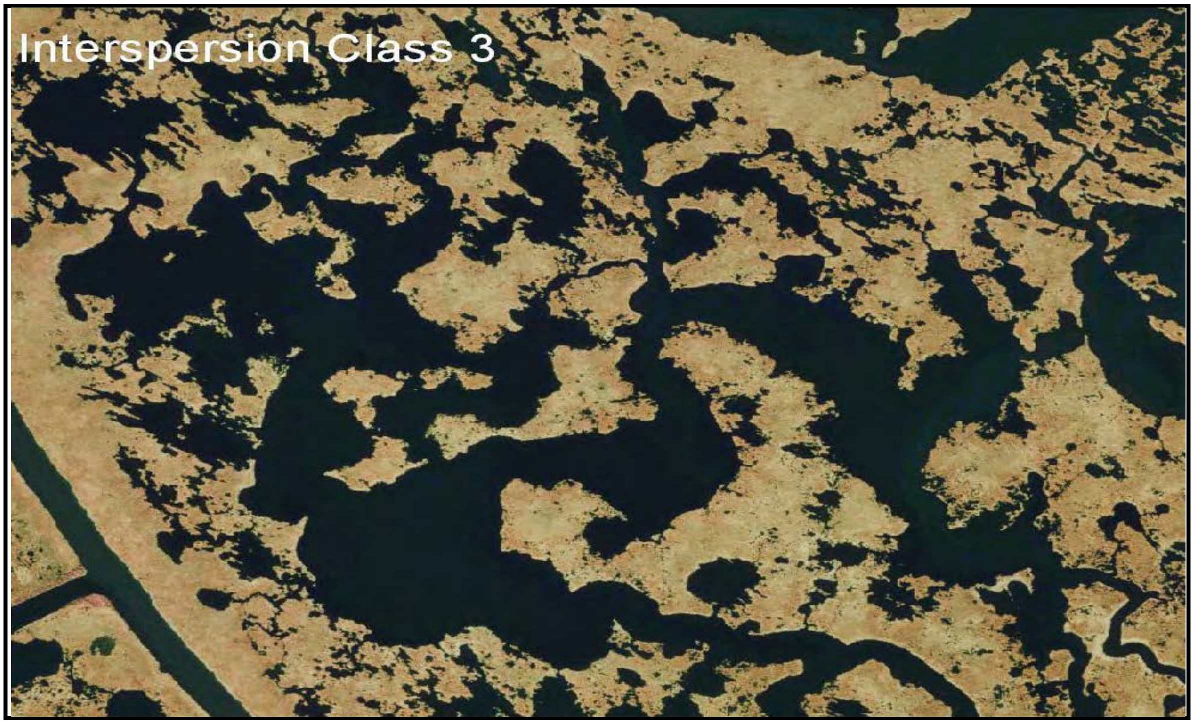

Figure P-3. Marsh Edge and Interspersion Class 3 (Roy, 2012)

Figure P-4. Marsh Edge and Interspersion Class 4 (Roy, 2012)

Variable 4 - Percent of the Open Water Area <= 1.5 Feet Deep. *This variable is the water depth based on the average water elevation in the project area. The baseline (TY0) value for this variable is usually determined based on data from field investigations, from elevation surveys, or from the personal knowledge of project planners, landowners, or land managers in the area. Water level data from staff gages or continuous recorders should be used whenever possible to determine the average water elevation, in the project area. Water depths should be recorded during the site visit at multiple locations throughout the project area. In many cases, the water depths recorded during the site visit can then be used with the water elevation data from the closest recording station for the same date and time as the site visit to determine the approximate bottom elevation. This will allow for an estimate of the depths in the project area with an average water elevation.*

A time series (~3 years) of water level data from a recording station (in the project area or close by) can be used to produce a cumulative distribution curve of the observed water levels. The water depths observed during the project site visit can then be placed in the overall water level frame. For example, if the measured depths were 2.5 feet and the site visit occurred during a time when the water levels were 1.0 foot higher than average, then the water depths under average conditions would be 1.5 feet. Previous WVAs for other projects in the area can also be helpful.

Future projections for V4 should consider marsh loss trends, the historic formation of open water habitat in the project area, subsidence, tidal exchange, sedimentation, and other factors which affect water depths. Few standard conventions have been adopted for projecting V4. One convention that has been adopted is the addition of a subsidence rate to the water depth measurements to determine a value for TY20 under FWOP. Subsidence rates can be obtained from the Coast 2050 Supplemental Appendices (Louisiana Coastal Wetlands Conservation and Restoration Task Force 1999). Essentially, subsidence (e.g., 0.5 in/yr) will result in increased water depths, and thus less shallow open water, over the project life.

For shoreline protection projects, the existing slope along the shoreline is usually held constant during future years, making the calculation of this variable somewhat easier. Open water habitat ≤ 1.5 feet created by terraces or unconfined dredged material disposal should also be considered. Future projections should be supported by monitoring data, scientific literature, examples of project success in other areas, previous WVAs, or personal knowledge of the project area.

Shallow water areas are assumed to be more biologically productive than deeper water due to a general reduction in sunlight, oxygen, and temperature as water depth increases. Also, shallower water provides greater bottom accessibility for certain species of waterfowl, better foraging habitat for wading birds, and more favorable conditions for aquatic plant growth. Optimal open water conditions in a fresh/intermediate marsh are assumed to occur when 80 to 90 percent of the open water area is less than or equal to 1.5 feet deep. The value of deeper areas in providing drought refugia for fish, alligators and other marsh life is recognized by assigning an SI=0.6 (i.e., sub-optimal) if all of the open water is less than or equal to 1.5 feet deep.

Shallow water areas in brackish marsh habitat are also important. However, brackish marsh generally exhibits deeper open water areas than fresh marsh due to tidal scouring. Therefore, the SI graph is constructed so that lower percentages of shallow water receive higher SI values relative to fresh/intermediate marsh. Optimal open water conditions in a brackish marsh are assumed to occur when 70 to 80 percent of the open water area is less than or equal to 1.5 feet deep.

The SI graph for the saline marsh model is similar to that for brackish marsh, where optimal conditions are assumed to occur when 70 to 80 percent of the open water area is less than or equal to 1.5 feet deep. However, at 100 percent shallow water, the saline graph yields an SI= 0.5 rather than 0.6 as for the brackish model. That change reflects the increased abundance of tidal channels and generally deeper water conditions prevailing in a saline marsh due to increased tidal influences and the importance of those tidal channels to estuarine organisms.

Variable V_5 – Salinity. *The baseline (TY0) value for this variable is usually obtained from salinity data collected along the coast. Salinity data can be obtained from published research (e.g., Swenson and Turner 1998, Steyer, et al. 2008) and from a number of sources online:*

NOS:	*http://co-ops.nos.noaa.gov*
USGS:	*http://la.water.usgs.gov/*
USACE:	*http://www.mvn.usace.army.mil/eng/edhd/watercon.htm* *http://www2.mvr.usace.army.mil/WaterControl/new/layout.cfm* *http://www.mvn.usace.army.mil/ops/locks/OTHER_lock_stat.htm*
CWPPRA:	*http://sonris-www.dnr.state.la.us*
CRMS:	*http://sonris-www.dnr.state.la.us*

It is preferable to use time series data for a station within or close to the project area as opposed to data from a field investigation which provides a one-time observation. The chief concern is locating an appropriate station for use in the analysis. Analysis of open water salinity data from the Barataria system by Swenson and Turner (1998) indicated R-squared values of ~0.7 for stations 20 kilometers apart and ~0.95 for stations 5 kilometers apart. Assuming that a correlation of 0.7 is acceptable then stations should be within 20 kilometers of the site. This approach is based on the assumption that the salinity in the freely connected open water at the site is indicative of the salinity in the marsh. Wiseman and Swenson (1988) investigated the relationship between salinity and water levels in the marsh (using continuous recording instruments along a 75 meter edge-inland transect) to salinity and water levels in the adjacent channel. The marsh water levels were highly coherent (coherence squared values of 0.8 to 0.98) with the channel water levels across time scales from hours to days. The marsh salinities exhibited much lower coherences (coherence squared values were all less than 0.8 with many below 0.5). They concluded that although overbank flooding is the dominant mechanism for salt to enter the marshes (on time scales of days to weeks) this input is not a simple linear relationship. Based on this, it is preferable to use salinity records from the marsh system as opposed to adjacent open water sites whenever possible. Internal marsh water level and salinity data are available (online) from CWPPRA monitoring records and through the Coastwide Reference Monitoring system (CRMS).

The salinity data is usually available at several sampling scales ranging from continuous hourly to discrete monthly. The preferred data is the continuous hourly or daily (daily 8 am or daily summary) both of which are also useful for identifying shorter term salinity spikes that may be affecting the system. Regression analysis of daily and monthly mean salinity estimates calculated from daily 8 am readings to means calculated from hourly data resulted in R-square values greater than 0.9 for ten locations in the Barataria-Terrebonne system (Swenson and Swarzenski, 1995). They concluded that daily readings are adequate to characterize the system. The salinity data is then used to calculate the *annual mean or growing season mean using as long a record as possible (a minimum of three years is desirable).*

It is assumed that periods of high salinity are most detrimental in a fresh/intermediate marsh when they occur during the growing season (defined as March through November, based on dates of first and last frost contained in Natural Resources Conservation Service soil surveys for coastal Louisiana). Therefore, mean salinity during the growing season is used as the salinity parameter for the fresh/intermediate marsh model. Optimal conditions in fresh marsh are assumed to occur when mean salinity during the growing season is 0.5 parts per thousand (ppt) or less. Optimal conditions in intermediate marsh are assumed to occur when mean salinity during the growing season is 2.5 ppt or less.

For the brackish and saline marsh models, average annual salinity is used as the salinity parameter. The SI graph for brackish marsh is constructed to represent optimal conditions when salinities are between 0 ppt and 10 ppt. The EnvWG acknowledges that average annual salinities below 5 ppt will effectively define a marsh as fresh or intermediate, not brackish. However, the SI graph makes allowances for lower salinities to account for occasions when there is a trend of decreasing salinities through time toward a more intermediate condition. Implicit in keeping the graph at optimum for salinities less than 5 ppt is the assumption that lower salinities are not detrimental to a brackish marsh. However, average annual salinities greater than 10 ppt are assumed to be progressively more harmful to brackish marsh vegetation. Average annual salinities greater than 16 ppt are assumed to be representative of those found in a saline marsh, and thus are not considered in the brackish marsh model.

The SI graph for the saline marsh model is constructed to represent optimal salinity conditions at between 0 ppt and 21 ppt. The EnvWG acknowledges that average annual salinities below 10 ppt will effectively define a marsh as brackish, not saline. However, the suitability index graph makes allowances for lower salinities to account for occasions when there is a trend of decreasing salinities through time toward a more brackish condition. Implicit in keeping the graph at optimum for salinities less than 10 ppt is the assumption that lower salinities are not detrimental to a saline marsh. Average annual salinities greater than 21 ppt are assumed to be slightly stressful to saline marsh vegetation.

Future projections for this variable are very important in determining the benefits for wetland restoration projects. Salinity is one of the most important factors affecting coastal land loss and decreasing salinities is the goal of many restoration projects. Salinity projections often directly affect projections for percent emergent marsh and percent SAV coverage and indirectly affect projections for marsh edge/interspersion and percent shallow open water. Future projections should consider changes in freshwater introduction and distribution, changes in the hydrology of the project area, and any other factors which may affect salinities. Historical data from the project area and recent trends can assist with future projections, especially under FWOP conditions. Monitoring data from freshwater diversion projects (e.g., Caernarvon Freshwater Diversion or West Point a la Hache Siphons) can also be helpful in determining FWP conditions for diversion projects. Modeling conducted for various projects (e.g., Brown Lake Hydrologic Restoration, Black Bayou Hydrologic Restoration, Hydrologic Investigation of the Chenier Plain, Hopedale Hydrologic Restoration) and COE feasibility studies (e.g., Lower Atchafalaya River Re-Evaluation Study, Morganza to the Gulf) can also be helpful.

Projects which reduce salinities under FWP are typically given credit for doing so at TY1. Those projects typically include features to either reduce saltwater intrusion or introduce fresh water to the system, both of which would have an immediate effect. Few standard conventions have been adopted for projecting V5. Future projections should be supported by monitoring data, scientific literature, examples of project success in other areas, previous WVAs, or personal knowledge of the project area.

Variable V_6 - Aquatic Organism Access. *Access by estuarine aquatic organisms (i.e., transient and resident species), is considered to be a critical component in assessing the quality of a given marsh system. Additionally, a marsh with a relatively high degree of access by default also exhibits a relatively high degree of hydrologic connectivity with adjacent systems, and therefore may be considered to contribute more to nutrient exchange than would a marsh exhibiting a lesser degree of access. The SI for V6 is determined by calculating an "access value" based on the interaction between the percentage of the project area wetlands considered accessible by aquatic organisms during normal tidal fluctuations, and the type of man-made structures (if any) across identified points of ingress/egress (bayous, canals, etc.). Standardized procedures for calculating V6 have been established (refer to pages 60-63). It should be noted that access ratings for man-made structures were determined by consensus among EnvWG members and that scientific research has not been conducted to determine the actual access value for each of those structures. Optimal conditions are assumed to exist when all of the study area is accessible and the access points are entirely open and unobstructed.*

A fresh marsh with no access is assigned an SI=0.3, reflecting the assumption that, while fresh marshes are important to some species of estuarine fishes and shellfish, such a marsh lacking access continues to provide benefits to a wide variety of other wildlife and fish species, and is not without habitat value. An intermediate marsh with no access is assigned an SI=0.2, reflecting that intermediate marshes are somewhat more important to estuarine organisms than fresh marshes. The general rationale and procedure behind the V6 Suitability Index graph for the brackish marsh model is identical to that established for the fresh/intermediate model. However, brackish marshes are assumed to be more important as habitat for estuarine species than fresh/intermediate marshes. Therefore, a brackish marsh providing no access is assigned an SI of 0.1. The Suitability Index graph for aquatic organism access in the saline marsh model is the same as that in the brackish marsh model.

The baseline (TY0) value for this variable is determined by a standardized methodology described in the model documentation. *A field investigation of the project area and examination of aerial photos is usually necessary to determine the baseline access value. Previous WVAs for other projects can also be helpful.*

Future projections for V6 should consider changes in access routes under FWOP and FWP conditions. In most FWOP scenarios, the access value does not change from the baseline value. Access may change under FWP depending on what types of structures are built as part of project implementation.

[Standard conventions for determining V6 have been adopted for various project types, including hydrologic restoration/marsh management, marsh creation, and shoreline protection. Conventions for marsh creation only are presented below because this is the only type applicable to this project]:

Marsh Creation - Marsh creation projects consist of an elevated marsh platform and typically utilize containment dikes to contain dredged material, thus impacting fisheries access. Marsh creation projects are typically designed to settle to an intertidal elevation by TY3 or TY5 and containment dikes are breached upon project completion or by TY3. Therefore, marsh creation projects are typically assigned an access value of 0.0001 (i.e., no access) at TY1 as the elevation of the marsh platform and/or presence of containment dikes do not allow fisheries access. The access value would increase to 1.0 when (typically TY3) it is estimated that the platform will settle (i.e., based on project design settlement curves, if available) to an intertidal elevation and the containment dikes are breached.

3. Habitat Suitability Index Formulas. *For all marsh models, V1 receives the strongest weighting* (Table P-2). *The relative weights of V1, V2, and V6 differ by marsh model to reflect differing levels of importance for those variables between the marsh types. For example, the amount of aquatic vegetation was deemed more important in a fresh/intermediate marsh than in a saline marsh, due to the relative contributions of aquatic vegetation between the two marsh types in terms of providing food and cover. Therefore, V2 receives more weight in the fresh/intermediate HSI formula than in the saline HSI formula. Similarly, the degree of aquatic organism access was considered more important in a saline marsh than a fresh/intermediate marsh, and V6 receives more weight in the saline HSI formula than in the fresh/intermediate formula. As with the SI graphs, the HSI formulas were developed by consensus among the EnvWG members.*

Table P-2. *Relative Contribution (%) of Each Variable to the Marsh and Water HSI Equations and the Overall (Total) HSI Equation*

	Fresh/Intermediate			Brackish			Saline		
Variable	Marsh	Water	Total	Marsh	Water	Total	Marsh	Water	Total
V1	64.8%	0.0%	43.9%	59.8%	0.0%	43.2%	58.3%	0.0%	45.4%
V2	0.0%	58.3%	18.8%	0.0%	46.7%	13.0%	0.0%	22.2%	4.9%
V3	11.1%	7.4%	9.9%	11.1%	7.4%	10.1%	11.1%	7.4%	10.3%
V4	0.0%	7.4%	2.4%	0.0%	7.4%	2.1%	0.0%	7.4%	1.6%
V5	11.1%	7.4%	9.9%	11.1%	7.4%	10.1%	11.1%	7.4%	10.3%
V6	13.0%	19.4%	15.1%	17.9%	31.1%	21.6%	19.4%	55.6%	27.5%

Source: Roy, 2012

In order to ensure that the value of open water components of the marsh environments to fish and wildlife communities is appropriately represented in the model, a spilt model approach is utilized. The split model utilizes two HSI formulas for each marsh type; one HSI formula characterizes the emergent habitat within the project area and another HSI formula characterizes the open water habitat. The HSI formula for the emergent habitat contains only those variables important in assessing habitat quality for marsh (i.e., V1, V3, V5, and V6). Likewise, the open water HSI formula contains only those variables important in characterizing the open water habitat (i.e., V2, V3, V4, V5, and V6). Individual HSI formulas were developed for marsh and open water habitats for each marsh type.

As with the development of a single HSI model for each marsh type, the split models follow the same conventions for weighting and grouping of variables as previously discussed.

4. Benefit Assessment. *As previously discussed, the coastal marsh models are split into marsh and open water components and an HSI is determined for both. Subsequently, net AAHUs are also determined for the marsh and open water habitats within the project area. Net AAHUs for the marsh and open water habitat components must be combined to determine total net benefits for the project.*

The weighting of the open water and marsh components reflects the relative value of these environments for fish and wildlife in each marsh type. A weighted average of the net benefits (net AAHUs) for marsh and open water is calculated with the marsh AAHUs weighted proportionately higher than the open water AAHUs. The weighted formulas to determine net AAHUs for each marsh type are shown below. Table P-2 shows the overall value of each of the variables after weighting.

Fresh Marsh:
$$\frac{2.1(\text{Marsh AAHUs}) + \text{Open Water AAHUs}}{3.1}$$

Brackish Marsh:
$$\frac{2.6(\text{Marsh AAHUs}) + \text{Open Water AAHUs}}{3.6}$$

Saline Marsh:
$$\frac{3.5(\text{Marsh AAHUs}) + \text{Open Water AAHUs}}{4.5}$$

(The following italicized sections are excerpts from Roy, 2010)

5. Subsidence and Sea Level Rise*. Subsidence and sea level rise (SLR) are assumed to affect FWOP and FWP scenarios. For most CWPPRA project evaluations (e.g., those within interior coastal areas), it is assumed that historical wetland loss rates calculated from a recent time period (e.g., 1985 to 2010) adequately capture the effects of subsidence and SLR for the relatively short analysis period of 20 years. However, for barrier island project evaluations, measures of subsidence and SLR are incorporated into many of the analytical modeling tools (e.g., SBEACH) used to determine project performance.*

B. Coastal Chenier/Ridge Community Model

1. Variable Selection. *Several existing Habitat Suitability Index (HSI) models were considered for use in determining migratory landbird stopover habitat quality, including the models for roseate spoonbill, great egret, brown thrasher, swamp rabbit, veery and yellow warbler. However, the emphasis for all these models was breeding habitat requirements. None addressed the set of variables that were determined to be most pertinent to assessment of stopover habitat quality, where a variety of species with differing foraging strategies occupy the habitat for a relatively brief time period. Selection of the variables used for this model was based upon a review of available literature, interviews with specialists who have studied various aspects of migratory landbird ecology in coastal stopover habitats, and the field knowledge of those involved with development of this model.*

More than 80 species of neotropical migratory landbirds from at least eleven Families pass through Louisiana during the spring and fall (Sauer et al. 2000). At the peak of spring migration, it is estimated that as many as 50,000 birds per day per mile of coastline enter the state (Conner *and Day 1987). During favorable weather conditions, the majority of these birds will bypass small wooded areas embedded in coastal marsh and land in extensive forested areas north of the marshes, but during thunderstorms or other unfavorable conditions, a large percentage of these individuals may stop in these small coastal wood patches (Gauthreaux 1971). Identifying the optimal stopover habitat characteristics for such a varied group of birds is challenging. Martin (1980) stated that migrants often select habitats en route that superficially resemble their breeding habitat. Moore et al. (1995) concluded that spring migrants on the northern Gulf of Mexico coast preferentially select structurally diverse stopover sites, consisting of forested areas with mixed shrub layers, and that maintenance of plant species and structural diversity should be a goal at migratory landbird stopover sites. Similarly, Martin (1980) found that habitat structure in shelterbelt "island" habitat in the Great Plains influences migrant diversity and abundance. Robinson and Holmes (1984) determined that the diversity of bird species in terrestrial habitats is correlated with factors associated with vegetation structure or composition, including diversity of foliage height, and stated that, in general, the number of bird species increases with the addition of vertical vegetation layers. Based upon the findings above and upon prior field investigations, we proposed three habitat assessment variables: 1) percent tree canopy cover, 2) percent shrub/midstory canopy cover, and 3) the number of native woody species planted/present on the site. We also identified some tentative variables, including percent herbaceous ground cover, minimum patch size, average tree height, and proximity of the site to other forested patches.*

We asked three specialists with expertise in the arena of migratory landbird habitat requirements to comment on our proposed habitat variables: William C. Hunter, U.S. Fish and Wildlife Service, Atlanta, GA; Mark Woodrey, U.S. Fish and Wildlife Service, Jackson, MS; and Wylie Barrow, U.S.G.S., National Wetlands Research Center, Lafayette, LA. Their comments have been incorporated into the model and referenced as personal communications.

All specialists queried concurred that structural and floristic diversity were key factors to consider. Additionally, they all stressed the importance of fresh water sources for springg trans-Gulf migrants. However, we did not develop a variable to capture this factor, as the model was being designed for created habitat in an area where fresh water input would probably be limited to precipitation. A variable to measure fresh water proximity should probably be created for assessing extant stopover sites. We decided not to use a variable for percent herbaceous ground cover because for the majority of birds that would be likely to use forested coastal areas, the amount of herbaceous ground cover would not be as critical a habitat need as would tree and shrub cover (Moore et al. 1995). Neotropical migratory landbirds dependent upon grasslands would not typically use forested cheniers, spoil banks, etc., instead gravitating towards marshes, pastures, and agricultural fields. No minimum patch size for sites was established, because while larger patches are accepted to be more valuable to birds than small patches, a small patch surrounded by non-forested habitat could be very important at times to migrants (Barrow, pers. comm.). The same basic rationale was used in determining that a variable to rank sites on the basis of their proximity to other forested patches was not practical. Sites adjacent to other forested sites are assumed to facilitate migration of forest birds by reducing the distance needed to travel through open and potentially inhospitable terrain, but an isolated woodland could be important during periods of inclement weather (Barrow, pers. comm.). Canopy height was ruled out as a variable because no data was discovered that addressed minimum canopy heights at stopover sites. The developers of this model assumed that percent canopy cover was a more pertinent variable to consider.

Variable 1 - Percent Tree Canopy Cover. *Neotropical migratory landbirds preferentially use stopover sites exhibiting high structural and floristic diversity (Moore et al.1995). To achieve the desired vertical plant diversity (i.e., a mix of trees, tree saplings, shrubs, vines, and herbaceous plants), a moderately closed tree canopy would be preferred to over a totally closed canopy (Hunter, pers. comm.; Barrow, pers. comm.; Woodrey, pers. comm.). Tree canopy coverage ranging from 65 - 85% is assumed to provide optimal conditions to allow for establishment of midstory trees, shrubs, vines, and herbaceous plants, provided that the site is not grazed. Tree species that may occur at coastal stopover sites include sugarberry (Celtis laevigata), toothache tree (Zanthoxylum clava-herculis), live oak (Quercus virginiana), water oak (Q. nigra), honey locust (Gleditsia triacanthos), red mulberry (Morus rubra), and green haw (Crataegus viridis) (Louisiana Natural Heritage Program 1988, Materne 2000, Gosselink et al. 1979,Thomas and Allen 1996, Thomas and Allen 1998).*

Variable 2 - Percent Shrub/Midstory Cover. *Shrub-scrub habitats provide important foraging and resting areas for migrant landbirds (Moore et al. 1995). Shrub-scrub habitats are also presumed to be important to migratory passerine birds as refuges from raptor predators (Moore et al. 1990). For the purposes of this model, shrub/midstory means multi-stemmed shrubs, single-stemmed midstory trees, single-stemmed saplings of overstory tree species, and woody vines. Shrub/midstory canopy coverage ranging from 35 - 65% is assumed to represent optimal conditions at a forested site. Species of shrubs, small trees, and woody vines that may be found at stopover sites include Small's acacia (Acacia minuta), wax myrtle (Morella cerifera), dwarf palmetto (Sabal minor), yaupon holly (Ilex vomitoria), saltbush (Baccharis halimifolia), greenbriars (Smilax spp.), grapes (Vitis spp.), prickly pear cactus (Opuntia spp.), Virginia creeper (Parthenocissus quinquefolia), pepper vine (Ampelopsis arborea), blackberries (Rubus spp.), rattlebox (Sesbania drummondii), marshelder (Iva frutescens), poison ivy (Toxicodendron radicans), Carolina wolf-berry (Lycium carolinianum), marine vine (Cissus incisa) and elderberry (Sambucus canadensis) (Louisiana Natural Heritage Program 1988, Materne 2000, Gosselink et al. 1979, Thomas and Allen 1996, Thomas and Allen 1998).*

Variable 3 - Native Woody Species Diversity. *A wide variety of fruits, flowers, nectars, and animals, primarily invertebrates, are consumed by migrant landbirds (Moore et al. 1995, Fontenot 1999, Barrow, pers. comm.). Robinson and Holmes (1984) concluded that vegetation provides birds with foraging opportunities and constraints depending upon the structure of individual plants, aggregations of plants, and the arthropods that these plants host. The resulting foraging conditions define the diversity of bird species in the habitat. While some exotic plant species provide foraging opportunities to migrant landbirds, others are of limited value to spring and fall migrant birds (Barrow and Renne, 2001, Barrow, pers. comm.). It is assumed that a variety of native shrubs, midstory trees, woody vines and overstory trees will provide sufficiently diverse foraging and resting habitat to enable spring and fall transient birds to continue their migration. Woody plant species composition and diversity in stopover habitat is influenced by elevation, soil type, and salinity levels (Materne 2000, Louisiana Natural Heritage Program 1988), and the capacity of sites to support certain species will depend upon these and other factors. Based upon a review of available written information and upon the field knowledge of those involved in development of this model, and upon the range of conditions likely to be encountered in stopover habitat in the area the model addresses, presence of 10 species of native trees, shrubs, and woody vines is assumed to represent optimal conditions. It is also assumed that the parameters defining optimal conditions for variables V1 and V2 will moderate the potential for variable V3 to exert a* *false reading of habitat value for migrant landbirds, should the diversity of plant species be confined only to trees, or to shrubs, or to woody vines.*

2. Habitat Suitability Index Formula. *The final step in model development was to construct a mathematical formula that combines all Suitability Indices into a single Habitat Suitability Index (HSI) value. Because the Suitability Indices range from 0.1 to 1.0, the HSI also ranges from 0.1 to 1.0, and is a numerical representation of the overall or "composite" habitat quality of the area being evaluated. Within the HSI formula, any Suitability Index can be weighted by various means to increase the power or "importance" of that variable relative to the other variables in determining the HSI. For this model, it was assumed that the variables are of equal weight in determining the habitat quality of a coastal chenier/ridge.*

To combine the variables into an HSI formula, a geometric mean was chosen, as opposed to an arithmetic mean, to convey the weak compensatory relationship between the three variables. An arithmetic mean is often used when it is assumed that the model variables have a strong compensatory relationship (i.e., a high value for one variable can compensate for the low value of another variable). The geometric mean is used to discourage a variable with a marginal or low suitability from being offset by the high suitability of the other variables (U.S. Fish and Wildlife Service1981). It was assumed that the three variables in this model do not have a strong compensatory relationship.

$$\text{HSI Calculation: } HSI = (SIV_1 \ \ x \ \ SIV_2 \ \ x \ \ SIV_3)^{1/3}$$

3. Benefit Assessment. *The net benefits of a proposed project are determined by predicting future habitat conditions under two scenarios: future without-project and future with-project. Specifically, predictions are made as to how the model variables will change through time under the two scenarios. Through that process, HSIs are established for baseline (pre-project) conditions and for future without- and future with-project scenarios for selected "target years" throughout the expected life of the project. Those HSIs are then multiplied by the project area acreage at each target year to arrive at Habitat Units (HUs). Habitat Units represent a numerical combination of quality (HSI) and quantity (acres) existing at any given point in time. The HUs resulting from the future without- and future with-project scenarios are annualized, averaged over the project life, to determine Average Annual Habitat Units (AAHUs). The "benefit" of a project is quantified by comparing AAHUs between the future without- and future with-project scenarios. The difference in AAHUs between the two scenarios represents the net benefit attributable to the project in terms of habitat quantity and quality.*

III. APPLICATION OF WETLAND VALUE ASSESSMENT

For this project, the HET conducted the WVA assessments. The HET included representatives from the USFWS, the NMFS, and the Corps. The project site was visited by the HET on December 13, 2012 to observe where constructible elements for the alternatives would be located, and assess current habitat conditions.

Because the footprints of Alternatives 1 and 2 are identical, as are the footprints for Alternatives 3, 4, and 5, WVAs were prepared for each of these sets of alternatives for impact assessment. Unavoidable habitat impacts for these sets of alternatives are displayed in Table P-3 by acres. Alternative 1has been chosen as the Recommended Plan. The WVA habitat assessment for Alternatives 1 and 2 employed the brackish marsh and chenier/ridge models, whereas the assessment for Alternatives 3, 4, and 5 used the brackish marsh and fresh/intermediate marsh models.

A 50-year planning period of analysis was used for these assessments. Intermediate target years were evaluated. In the case of WVAs for marsh impacts and marsh restoration measures, as many as five intermediate target years for the future with project condition were assessed.

Coastal land loss rates accounting for subsidence and shoreline erosion were established for the project area, and this information was used in all marsh project impact and mitigation assessments. Land loss rates for the Calcasieu Ship Channel South subunit, an area larger than the immediate Calcasieu Lock project area, were used to represent land loss rates the project area (Barras et al. 2008). Land loss rates were adjusted by the projected effects of three Relative Sea Level Rise scenarios. The medium Relative Sea Level Rise scenario was chosen for the marsh WVA analyses. In contrast, for forested spoil bank habitat it was assumed that land loss due to subsidence and shoreline erosion would not affect the spatial extent or habitat conditions of this terrestrial resource, which is located along the south side of Calcasieu Lock. Therefore, land loss was not incorporated into the chenier/ridge project impact and mitigation assessments.

Salinity conditions for the project area were determined by analyzing available salinity measurements taken at the Calcasieu Lock West and East Gages. For salinity conditions in brackish marsh, data from the West Gage was used, and for intermediate marsh, readings from the East Gage were used.

A. WVAs for Impact Assessment. Information sheets describing the WVA habitat impact assessments are provided in Appendix P-1. In addition to land loss rate information, these sheets include explanations of information used or assumptions made for each variable in the models, whether under existing, future without project, or future with project conditions.

B. WVAs for Potential Measures to Offset Unavoidable Adverse Impacts. Because habitat impacts are unavoidable, measures to offset these losses to coastal marsh and forested spoil bank habitats are required. In addition to assessing habitat impacts, WVAs were prepared for assessing potential marsh habitat restoration and creation measures, as well as forested spoil bank habitat enhancement and replacement measures to replace lost ecological functions. Based on these WVA restoration assessments, the need for compensatory mitigation was identified.

Table P-3. Unavoidable Direct Impacts by Habitat Type for Calcasieu Lock Alternatives

Impacts	Upland Forested Ridge Habitat-Existing Spoil Disposal Area	Brackish Marsh-Emergent Vegetated & Associated Water	Brackish Marsh-Open Water Within Marsh (Bayous, Ponds)	Intermediate Marsh-Emergent	Intermediate Marsh-Open Water	Deeper Open Water-Not a WVA Calculation (GIWW, Black Bayou)	Total
ALTERNATIVES 1 AND 2							
Acres	11.5	9.7	4.3	0	0	0	25.5
AAHUs	-7.5	-3.78		0	0	0	-
ALTERNATIVES 3,4,5							
Acres	0	4.9	5.5	18.9	4.3	(51)	33.6
AAHUs	0	-1.56		-7.51		0	-9.07

1. Potential Marsh Restoration Measures. Information sheets describing the WVA marsh restoration assessments are provided in Appendix P-2. To develop a restoration/creation potential for brackish marsh losses, an assumed restoration alternative was assessed and consisted of converting three open water remnants of historic Black Bayou on the west side of Highway 384 into brackish marsh using hydraulically dredged material obtained from construction of the project. These open water areas are surrounded by brackish marsh and total about 30.9 acres. Similarly, to develop a restoration potential for intermediate marsh losses, an assumed restoration alternative was evaluated and consisted of converting one open water remnant of historic Black Bayou on the east side of Highway 384 into intermediate marsh using hydraulically dredged material obtained from the project. This 4.3-acre open water area is surrounded by intermediate marsh.

An initial evaluation was developed under the assumption that all marsh restoration/creation areas would be actively planted with herbaceous marsh plantings. Later, a second evaluation was conducted without any active marsh plantings.

To develop marsh restoration/creation plans, the benefit of these assumed compensatory alternatives in AAHUs was compared with the project impact of losing marsh habitat in AAHUs. If the initial comparison showed an overall new loss, then the scale of these compensatory alternatives could be adjusted either up or down to identify how much of each alternative would be needed to offset project impacts.

Potential marsh restoration/creation areas would be confined by earthen dikes constructed to contain the dredged material. These areas would then be filled with dredged material, which would consolidate to form a substrate for the establishment of intertidal marsh. A WVA was prepared to identify marsh and estuarine habitat improvements as a result of dredged material placement.

The dikes around the cells would be designed to slowly deteriorate and subside to the level of the adjacent marsh substrate, thereby promoting the tidal exchange of water. Earthen dikes may require mechanical degradation to the settled elevations of the disposal area if natural erosive processes do not degrade them sufficiently to meet fisheries and tidal access needs. Such breaches would be undertaken after consolidation of the dredged sediments and vegetative colonization of the exposed soil surface—approximately two to five years after pumping. For the purposes of the WVAs, it was assumed that dikes would be degraded 3 years after pumping, whether naturally or mechanically.

The following features are applicable to the assumed marsh restoration/creation alternatives:

- Dredge material slurry would be allowed to overflow existing emergent marsh vegetation within the project area, but would not be allowed to exceed a height of approximately 1foot above the existing marsh elevation. Tidal inlets and channels may be created during the pumping of dredge material and by natural tidal fluctuations.
- The target elevation of placed and consolidated fill at each site would be determined through geotechnical analyses during the preparation of plans and specifications for the project. These analyses would consider long-term settlement of the dredged materials and placement area foundations, as well as elevation surveys of adjacent marsh to determine the appropriate target range. These elevation targets would be coordinated with resource agencies prior to construction.
- Vegetation of marsh restoration/creation areas would rely on natural recruitment and well as some active planting.

2. Potential Forested Spoil Bank Restoration Measures. Information sheets describing the WVA chenier/ridge restoration assessments are provided in Appendix P-3. Restoration potentials were assessed for two assumed alternatives: 1) restoring 16 acres of degraded natural forested ridge habitat, and 2) implementing tree strand improvements in approximately 15 acres of remaining forested spoil bank habitat.

Restoring degraded natural ridge habitat would consist of replacing lost native woody vegetation on intact natural ridges that have only herbaceous groundcover by planting tree and shrub species. Tree stand improvements would consist of measures to increase the abundance and diversity of native woody species in the existing forest, including the planting of native tree and shrub species, creation of selective clearings or removal of undesirable vegetation, and removal of invasive species using accepted mechanical or chemical methods, such as Chinese tallow tree which is prevalent in the forested spoil bank habitat.

IV. RESULTS

The WVA models forecast the net marsh and forested spoil bank/ridge habitat losses of implementing Alternatives 1 and 2 and Alternatives 3, 4, and 5, for a period of analysis starting the year project construction begins and ending 50 years after the start of the project. Table P-3 shows a summary of these net losses for the two sets of alternatives.

Table P-4. Potential Compensatory Measures Evaluated for Unavoidable Impacts to Marsh & Forest Habitats

Potential Restoration Measures	Acres	Net Gain AAHUs	Restoration Potential (AAHU/acre)
Brackish Marsh - convert open water to marsh in a beneficial use manner at three historic remnants of Black Bayou on west side of Hwy 384	30.9	14.78[1]	0.48[1]
Intermediate Marsh - convert open water to marsh in a beneficial use manner at one historic remnant of Black Bayou on east side of Hwy 384	4.3	1.85[1]	0.43[1]
Forested Spoil Bank/Ridge Habitat – restore natural degraded ridge habitat south of project area at unidentified site	16.0	7.91	0.49
Forested Spoil Bank/Ridge Habitat – implement tree stand improvements within remaining forested spoil bank habitat	15.0	3.12	0.20

[1] Reflects WVA analysis with marsh plantings

As displayed in Table P-3, Alternatives 1 and 2 would result in the unavoidable losses of 3.78 AAHUs (14.0 acres) of brackish marsh and 7.5 AAHUs (11.5 acres) of forested spoil bank/ridge habitat. Similarly, for Alternatives 3, 4, and 5 these losses were forecasted as 7.51 AAHUs (23.2 acres) to intermediate marsh and 1.56 AAHUs (10.4 acres) to brackish marsh.

The WVA models also forecast the benefits of restoration measures to compensate for these unavoidable losses, for the same period of analysis. Table P-4 displays a summary of these net potential benefits by habitat type.
As displayed in Table P-4, the restoration and creation of brackish marsh in a beneficial use manner at several open water sites totaling about 31 acres within the project area would generate nearly 15 AAHUs of habitat benefits. Because this potential benefit is considerably more than the

3.78 AAHU loss associated with Alternatives 1 and 2 (Table P-3), it would more than offset the loss.

Refinement of the design for Alternative 1 (Recommended Plan) has continued following the public review period for this project in 2013, and the amount of dredged material to be obtained from excavation of the new channel has increased from an initial estimate of 170,000 cy to 233,000 cy. Therefore, 50 acres of marsh restoration/creation are expected. An updated WVA analysis for 50 acres of marsh restoration/creation without any marsh plantings shows that 23.5 AAHUs would be generated.

A similar comparison for Alternatives 3-5 shows that using dredged material for marsh restoration/creation would also offset all adverse impacts. Therefore, no compensatory mitigation would be required for marsh losses associated with all project alternatives.

To compensate for forested spoil bank/ridge habitat losses associated with Alternatives 1 and 2, the WVA assessments forecast potential benefits for two different kinds of restoration measures or alternatives. One of these, restoring an assumed 16 acres of degraded natural ridge habitat, would potentially offset the losses associated with Alternatives 1 and 2 (Tables P-3 and Table P-4). This particular WVA assessment was for an unidentified site, as natural chenier/ridge habitat occurs to the south of the project area at least 15 miles away, and a search of potential restoration sites was not conducted by the HET as part of this study. The feasibility of implementing this restoration alternative could be examined during the PED phase.

The second forested spoil bank/ridge restoration alternative—implementing tree stand improvements in the remaining 15 acres of habitat—forecast that the benefits generated from doing this (3.12 AAHUs) would not be enough to offset the losses (7.5 AAHUs) associated with Alternatives 1 and 2.

Therefore, adverse effects to forested spoil bank habitat associated with Alternatives 1and 2 would require compensatory mitigation to offset these losses. Appendix I, *Mitigation Plan*, provides detailed information about the mitigation planning and mitigation plan development that was conducted for this project.

V. SENSITIVITY ANALYSIS

An ecological sensitivity analysis was performed for this project to evaluate uncertainties in the WVA marsh analyses. Reviewers of Version 1.0 of the Coastal Marsh Community WVA model suggested an alternative treatment for the HSIs for three model variables involved in WVA marsh models: Suitability Index Value (SIV)1 – Percent of wetland area covered by emergent vegetation, SIV2 – Percent of open water area covered by aquatic vegetation, and SIV3 – Marsh edge and interspersion. An Excel file named “Interim WVA V1.4.xlsx” has been developed for the purpose of conducting such a sensitivity analysis, and was employed for this project. The sensitivity of the WVA marsh model outputs to the suggested changes in SIV1, SIV2, and SIV3 was assessed for the marsh impact analyses as well as the marsh creation/restoration analysis. The sensitivity analyses are included at the end of this appendix. Version 1.1 of the marsh model was used for this study. The difference between this version and Version 1.0 is limited to some changes in spreadsheet formatting and minor changes to the appearance of text; there are no changes in calculations.

For the marsh impact analysis associated with Alternatives 1&2 (loss of 14 acres brackish), the CWPRRA model produced an output of -3.8 AAHUs, whereas the alternative treatment of adding Emergent Marsh (EM) and OW (open water) to the CWPRRA model produced an output of -4.6 AAHUs, or a difference in outputs of 21% .

For the marsh impact analysis associated with Alternatives 3-5 (loss of 11 acres brackish and 23 acres intermediate), the CWPRRA model produced an output of -1.6 AAHUs for brackish marsh and -7.5 AAHUs for intermediate marsh. The alternative treatment of adding Emergent Marsh (EM) and OW (open water) to the CWPRRA model produced an output of –2.1 AAHUs for brackish marsh and -12.0 AAHUs for intermediate marsh. These differences in outputs are 31% for brackish marsh and 60% for intermediate marsh. Therefore, applying the alternative treatment to the CWPRRA model would increase total impacts to marsh from -9.1 to -14.1 AAHUs, with a difference of 55%.

For the marsh creation/restoration analysis developed for Alternatives 1&2, based on placing dredged material into shallow open water areas to restore and create marsh 50 acres of brackish marsh, the CWPRRA model produced an output of 23.5 AAHUs. In contrast, the alternative treatment of adding Emergent Marsh (EM) and OW (open water) to the CWPRRA model produced an output of 9.8 AAHUs, for a difference of 58%.

For the marsh creation/restoration analysis developed for Alternatives 3-5, based on placing dredged material into shallow open water areas to restore and create marsh 35 acres of brackish marsh, the CWPRRA model produced an output of 16.6 AAHUs. In contrast, the alternative treatment of adding Emergent Marsh (EM) and OW (open water) to the CWPRRA model produced an output of 6.9 AAHUs, for a difference of 58%.

With respect to Alternatives 1&2, the overall effect of applying the alternative treatment to the CWPRRA model would not change the results of the habitat assessment. The ecological benefits generated from marsh restoration/creation using dredged material (9.8 AAHUs) would still outweigh the marsh losses (-4.6 AAHUs). There would be no need for compensatory mitigation, and the costs associated with these alternatives would not change.

With respect to Alternatives 3-5, the overall effect of applying the alternative treatment to the CWPRRA model would change the results of the habitat assessment. The ecological benefits generated from marsh restoration/creation using dredged material (6.9 AAHUs) would not outweigh the marsh losses (-14.1 AAHUs). There would be a need for compensatory mitigation to make up the difference of 7.2 AAHUs. The costs associated with Alternatives 3-5 would need to increase to account for this compensatory mitigation. A rough estimate of such costs is $1.2M, assuming 15 acres of marsh credits needed to be purchased from a mitigation bank.

The overall effect of applying the alternative treatment to the CWPRRA model would not change the selection of Alternative 1 as the Tentatively Selected Plan/Recommended Plan.

VI. REFERENCES

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